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INTERRELATIONSHIP OF IN-SITU ROCK PROPERTIES EXCAVATION METHOD, AND MUCK CHARACTERISTICS

H. F. Haller, et al

Holmes and Narver, Incorporated

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INTERRELATIONSHIP OF IN-SITU ROCK PROPERTIES, EXCAVATION METHOD, AND MUCK CHARACTERISTICS

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	bruary 16, 1972 - July 31, 1973
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13. ABSTRACT	
Reports results of research to correlate	the properties of in-situ rocks with
materials handling properties of muck as	
Goals are to develop methods for predict	
ted data and for selection of transport	
Number concept. Muck sample, rock, and	
methods, data processing, development of	
ment selection are described. Data for	
sites are presented in raw data printout	
	rating data, muck properties, and equip-
	composite size and distribution curves,
with regression analyses of 47 data set	
percent. Applications to equipment sel	
formulas used in design of helt and hyd	
tions include more rational transport e	
resultant speed and cost benefits. Rec	
sampling operations and formations not	previously available, resampling to
improve the confidence level of the data	a, testing for abrasiveness in addi-
tion to tests previously performed, and	
of computerized methods for defining ha	rdware, computer simulation of tunnel
systems, and field verification of the	concepts are also recommended.

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Final Technical Report

INTERRELATIONSHIP OF IN-SITU ROCK PROPERTIES, EXCAVATION METHOD, AND MUCK CHARACTERISTICS

by H. F. Haller H. C. Pattison Dr. O. C. Baldonado

Sponsored by
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FOREWORD

This report presents the results of a research program, completed in 1973, into the interrelationships of in-situ rock properties and the characteristics of muck produced by various excavation methods. The authors wish to express their appreciation and that of Holmes & Narver, Inc., for the assistance provided by the many U. S. Bureau of Mines and Holmes & Narver staff members, as well as those individuals and organizations listed below who also participated in the program.

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INTRODUCTION AND SUMMARY

PURPOSE

The purpose of the program is to develop a method for predicting the materials handling properties of muck from the engineering properties of rock and the parameters of excavation systems, and means of selecting the most suitable transportation equipment for the muck through the concept of Muck Designation Numbers (MDN).

MDN range in whole numbers from 1 through 7. MDN 1 describes muck with a large maximum piece size, more than 20 percent plus 6-inch material, and a predominant distribution in the plus 1/2-inch size range. The maximum size of MDN 7 is relatively small; the predominant distribution is minus 1/2 inch, and more than 5 percent is minus 100 mesh in size. Intermediate numbers range in size and size distribution between end points. The concept recognizes that muck characteristics vary with excavation methods as well as rock properties.

SCOPE

This report describes results of research performed under an eighteen-month contract initiated on February 16, 1972. The work is a continuation of a previous 1-year contract the results of which also are summarized to present the total accomplished and the current status of the program.

CONCLUSIONS

Program activities have included sample and data collection, physical testing, data storage and processing, development of MDN, correlation with rock properties, establishing the parameters of muck handling systems, and illustrations of MDN applications to subsystem and hardware selection.

Regression analysis of 27 sets of rock property, Raise Boring Machine (RBM), and Tunnel Boring Machine (TBM) data produced a predictor equation with an apparent accuracy over 80 percent. Analysis of 20 sets of rock data with conventional excavation parameters produced an equation with an apparent accuracy of more than 90 percent.

An expected drop in apparent predictor accuracy to below preliminary levels did occur, and appropriate parameters remain to be developed for shield and drag cutter TBMs. However, it is concluded that MDN are predictable within the limits of reasonable

accuracy for the majority of rocks and methods sampled under the program.

The examples show that MDN can be used to eliminate some transport subsystems from consideration, and to define the hardware required for use in the subsystems which are applicable. They also support a conclusion that computerized procedures for hardware definition should be developed. Areas which appear to require clarification prior to this development, and means of developing systems simulation as a construction planning tool are discussed.

REFERENCE TO DETAILS

Details of the topics summarized below are arranged under the same headings in the report.

SUMMARY

1. Technical Problems

Inadequate subsurface information on new tunnels limits the effectiveness of construction planning and forces contractors to base bids on methods and equipment which may not suit the job. Loss of time, lives, and money has often resulted.

Estimates of the volume of tunnel construction made several years ago focused attention on the importance of a more logical approach to methods and equipment selection. The advisability of increasing excavation speed while reducing costs has been reemphasized by recent studies which show that prior tunneling forecasts were conservative.

Muck transportation obviously is a major factor in tunnel cost; improvements would reduce tunnel costs significantly. Knowledge of the basic properties of a material is fundamental to improvement of handling techniques. Prior to the inception of the MDN program, however, practically no information had been collected on muck characteristics; and correlations between muck properties, the properties of the in-situ rock, and the components of rapid excavation systems had not been established.

These data are essential as a basis for optimum selection from the transportation systems in current use and for development of the high speed systems required in the future. A need also exists for fast, accurate means of defining the hardware required for some subsystems, and for comparing the performance of different total systems or of systems with varied arrangements of components.

2. General Methodology

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The research plan was to collect muck samples, lithologic and operating data, and rock specimens where necessary from operating tunnels; determine muck characteristics and rock properties by physical testing; correlate and analyze rock and muck properties and quantify relationships through MDN; and correlate rock and muck characteristics, MDN, and the components of rapid excavation systems with muck transport system capabilities.

Lithologic data consists of descriptions of rocks, their classification by probable origin and subsequent alteration, and Rock Quality Designations (RQDs) which indicate the frequency of discontinuities. Operating data includes descriptions of the equipment and methods used in the total excavation system. Rock test data includes unconfined uniaxial compressive strength, dry unit weight, hardness, and stress-strain relationships known as Young's modulus and Poisson's ratio. Commercial muck test data includes size distribution, shape, moisture content, dry loose unit weight, and abrasiveness. Additional muck tests by the Pittsburgh Mining and Safety Research Center (PMSRC) determine Atterberg limits, potential volume change, specific gravity, angles of repose, slide, and internal friction, apparent cohesion, and bulk density.

3. Technical Results

3.1 Site Selection

A list of current and scheduled tunnels, originally compiled to assure that program objectives could be met, was revised periodically. Excerpts from the last revision are included in Appendix A. Sites for data and sample collection were selected with emphasis on mechanical operations in hard rock. In the first year, some soft rock and conventional tunnels were included as examples of unusual advance rates and systems. In the second year, conventional operations in hard rock at deep mine sites were sampled at client request. Information peculiar to such sites is summarized in Appendix A.

3. 2 Sample and Data Collection

In the current program, operating data and 18 muck samples were collected from eight sites. Totals for the program are 52 samples from 23 sites. Resampling at four sites confirmed the reliability of initial results. All other samples reflect differing lithologies, operating methods, or equipment.

Rock specimens for engineering property tests have been collected from 41 formations at 22 sites. Twenty-one of the specimens, some of which represent formations sampled in 1971, were collected from ten sites in 1972.

Two shield, two RBM, 19 conventional, and 29 TBM operations have been sampled to date. Rock types sampled include four classified as Very High Strength, 27 High Strength, nine Medium, Lix Low, and six Very Low Strength. The basis for these classifications follows in the body of the report.

3.3 Physical Testing

Standard tests, approved by the American Society for Testing Materials and/or the U. S. Bureau of Mines, were selected for use by commercial laboratories to ensure consistency of results.

Contracts to perform muck tests were negotiated with 18 commercial laboratories. Samples were delivered for testing and shipment of fractions to the U. S. Bureau of Mines, PMSRC, for additional tests. Under the current contract, the volume of these fractions was increased from 2 to 4 cubic feet. One set of samples tested commercially was lost in transit to the PMSRC.

Contracts to perform rock tests were negotiated with five commercial laboratories. Forty-one sets of rock specimens were collected and tested. Stress-strain data from testing initiated in 1972 were obtained on 24 rocks including six collected in 1971. Schmidt hardness tests, also initiated in 1972, were completed on 33 cores and rock specimens by test methods modified to produce acceptable results. No abrasiveness tests were possible because equipment which was planned for use was not available.

3.4 Data Processing

Formats were developed for storage and printout of lithologic rock, muck, tunnel and transport capability data; all data have been stored on punch cards and printouts, "Raw Data Sheets" are presented in Appendix B. A form was developed for narrative and graphic presentation of data in the "System Data Sheets", included as Appendix C.

3.5 Development of MDN 3.

3.6 Data Analysis

Size distribution curves from initial sampling varied distinctly, generally as had been expected; an algorithm to correlate MDN, in-situ rock properties, and excavation methods was developed as described in Appendix D. Continued sample testing produced some curves which fit well with the initial curves, and others which suggested establishing additional categories. Using the data available at the end of the first year, curves of similar form were plotted together, and preliminary MDN were assigned.

Initial regression analyses produced predictor equations indicating accuracies over 90 percent for RBM/TBM and for conventional operations. MDN assignments were modified and consolidated, and additional iterations were performed when all data collected were in final form. Values for Young's modulus, Poisson's ratio, and Schmidt hardness resulting from second year tests were substituted for the less important parameters and inferred values used in the preliminary analyses. Indicated accuracies of prediction were over 80 percent for machine operations and 90 percent for conventional. Composite curves for each MDN, computer input data, and output tabulations are shown in Section 3 of the text.

3.7 Transport System Selection

A list of equipment capabilities, system constraints, and MDN applications has been included in Appendix E. Belt and hydraulic conveying system design parameters and available parametric mathematical models of these systems were studied under the current program. Collected muck property data were used as input to design formulas in examples of MDN data use for design of belt and hydraulic conveying systems. Examples of MDN applications to other systems are shown. Detailed calculations supporting the examples are shown in Appendix E.

4. DoD Implications

The advantages of underground siting for many DoD installations, and the necessity of such sites for some facilities are well known. The impact of one or many joint-use underground installations on national defense capability, and the importance of tunneling to weapons test programs require no evidence in this report. It is obvious that any action to improve the efficiency of muck handling will affect significant parts of DoD and national budgets in the future.

Data accumulated under the program, nonexistent elsewhere in rapid excavation technology, can provide a more rational basis for selection of materials handling systems for excavation methods in current use. These data will also be invaluable to the design of the equipment required to match the improved advance rates resulting from current excavation research. As alternatives to design of systems to handle a specific type of muck, MDN data can be used to select process equipment to change muck characteristics to suit a system, or to select separation and supplementary haulage equipment for the oversize fraction of muck which cannot be handled by a continuous system which is otherwise well adapted to a site.

MDN provide basic data required for a rational engineering approach to problem solutions in a most important subsystem of the rapid excavation process. The examples illustrate data application and identify areas in which improvement is possible. Further use of MDN data should be made to indicate the areas in which research and development of modifications or new methods would be most productive.

5. <u>Implications for Further Research</u>

5.1 Sample and Data Collection

Recommendations for further research are based in part on the following tabulation of formations and excavation systems for which data are available at the end of the current contract.

Excavation	Rock Strength									
Method	Very High	High	Medium	Low	Very Low	Total				
Conventional	3	9	5	l	1	19				
Shield	0	0	0	0	Ž	2				
Machine Drag Cutters Disc Cutters Roller Cutters Combination Cutters	0 2 0 0	1 7 3 3	1 5 1 1	1 0 1	1 0 0 2	5 15 4 7				

To be consistent with good sampling and testing practices, data reliability should be confirmed by repetition of all single samples. Statistically, the number of samples used in development of a predictor equation should be greater than the number of variables in the analysis. To improve prediction reliability additional samples, detailed in the body of the report, should be collected from all types of TBMs in selected formations.

To demonstrate variations in muck characteristics with rock properties, conventional and selected TBM samples should be collected from the Medium and Low Strength rocks. To provide data on the full range of rock types, stratified volcanic and fine-grained igneous rocks should be sampled. Sampling muck from tests of unusual rock breaking techniques which may become the standards of the future should be initiated to provide data on the muck for which transport systems may be required.

Within the scope of the program, useful operating parameters could not be developed for Atlas-Copco and Alpine machines or for the effective torque applied by other TBMs. Since the two named machines may become important types of equipment for special use, and torque data have been approximated in analysis of other machine operations, future research to develop these parameters is recommended.

5.2 Physical Testing

Continued testing is recommended for the physical property data collected in the past since all commercial test results appear to be important to one of the predictor equations, and the PMSRC test data remains to be evaluated.

Abrasiveness testing should be initiated as soon as possible to provide data for cost analyses. Investigation of the Protodyakonov test for resistance to fragmentation is recommended to determine the effect of a second dynamic property on prediction accuracy.

5.3 Data Analysis

Additional regression analyses should be run to test the effect of using other data and data combinations than those which were possible under the current program, and to review the data input to determine what modifications would be valid.

5.4 Methods Development

Computer methods should be developed in the public domain to define rapidly and accurately the hardware required for those systems for which manual procedures are time-consuming and expensive. Systems simulation data and programs should also be developed to provide a fast means of comparing the performance of different systems or of varying the components of a single system. Wide publicity in lay terms should be given to such developments to accelerate their acceptance by industry.

5.5 Concept Validation

The validity of the MDN concept should be tested in practice by predicting muck characteristics and selecting equipment for proposed tunnels, and comparing the predictions and the selected transport systems with the muck produced and the systems actually used.

6. Special Comments

A Schmidt impact rock test hammer and two self-rescuers were purchased during the reporting period for use in the program. No invention has been made in the course of the work performed under this contract.

1. TECHNICAL PROBLEMS

The effectiveness of planning for new tunnels has been limited by the subsurface information which has been available. Owners and owner-agencies often have been reluctant to collect data on the properties of materials to be excavated, or to publish information which has been collected. Interested contractors are forced to base proposals on inadequate data and cost estimates on methods and equipment which may not be best for conditions as they exist. Generally, significant allowances are made for contingencies.

The importance of a more logical approach to selection of methods and equipment for turneling was reemphasized by recent studies which indicate that prior estimates of demand were conservative. Wider application of tunnel boring machines, which require rock property data for design, and of an engineering approach to ground support have influenced owner and agency policies to collect and disseminate more and better quality exploratory information.

Progress has been made in research to determine relationships between rock properties, drillability, excavation, and ground support. Prior to the current program practically no information had been collected on the characteristics of muck; and correlations between rock and muck characteristics and the components of excavation systems had not been established.

In the absence of muck characteristic data, an adequate basis for selection of transportation subsystems and equipment does not exist, and tunneling progress and cost have been affected adversely. Muck data are also basic requirements for engineering the improvements to existing transport systems and the development of the new systems which will be necessary to keep pace with future excavation rates.

When a concept such as the MDN becomes a reliable predictor for muck characteristics, work remains to be done to provide rapid, accurate methods of defining the hardware required by several possible transport methods, and determining their relative capabilities. Studies of design methods used for belt and hydraulic conveying systems show that as manual procedures, they are tedious, repetitive, and mathematical; faster and less expensive methods would encourage greater use of results. Production and cost comparisons between subsystems, and between different arrangements of a single system are also time-consuming, and become more complicated as injuries and other unscheduled delays are incorporated in an analysis. A more rapid and economical means of comparing alternates would facilitate selection of optimum systems and components.

2. GENERAL METHODOLOGY

The objectives of the program are to develop a method for predicting the materials handling properties of muck from the in-situ properties of rock and the characteristics of excavation systems; and a means of selecting the most suitable transportation systems and equipment for the muck produced. The major emphasis is on mechanical excavation of hard rock. However, some soft rock and conventional operations are included as examples of unusual advance rates, equipment, and operating methods; and to provide comparators to demonstrate those differences which exist.

The program plan is to collect muck samples and operating data from tunnels and mining projects in rock of known properties; collect specimens from sites where the in-situ properties are unknown; determine muck characteristics and rock properties by physical testing; correlate and analyze rock and muck properties and quantify relationships through the concept of Muck Designation Numbers (MDN); and to establish correlations between rock and muck characteristics, MDN, rapid excavation systems, and muck transport equipment.

3. TECHNICAL RESULTS

3.1 SITE SELECTION

A list of operating and scheduled tunnels, prepared originally to assure that program objectives could be met, has been revised periodically to reflect new starts and completions. Anticipating completion of the program, the last revision was made in September, 1972. Excerpts from that list are reproduced in Appendix A to illustrate the form and content. No other listing of this information is known. Letter inquiries inviting program participation by off-continent tunnel operators met with no response.

Tunnel contractors, although under no obligation to participate in the program, have been most cooperative. Operating mine cooperation has been equally good, although access usually requires more operator support, and the impact of economic conditions has reduced emphasis on research. Sample and data collection on a strictly noninterference basis, and full observance of safety requirements have been important in gaining operator acceptance.

Early planning assumed that one basis for site selection would be the availability of rock property data at specific sites. Experience proved that collection of these data is necessary from the majority of locations, and the program was modified to reflect this requirement.

In the first half of 1971, it became apparent that sampling tunnel operations in a wide range of rock strengths and excavation techniques would be necessary to demonstrate that muck characteristics vary distinctively with rock characteristics and operating methods. The program plan was modified to provide for data collection in the variety possible within the limits of time and availability, an additional funds were provided by contract modification to enlarge the scope of field sampling.

In the first year of the program, sites were selected to provide one-third of the samples from conventional excavation. In the second year eight conventional and ten mechanical operations were sampled. In response to a client request to obtain samples and data from conventional operations in strong rocks at maximum depth during 1972, sites were selected for field work in two quartzites at 7,094 feet and 6,100 feet, a phyllite at 6,200 feet, a conglomerate at 3,960 feet, and a graywacke at 3,480 feet below the surface. At some sites, planned sampling of stronger rocks and/or at greater depths could not be accomplished because of site conditions.

3.2 SAMPLE AND DATA COLLECTION

Muck samples and operating data were collected from 23 mine and tunnel sites. Of 52 samples, 11 were collected from sites visited only once. Resampling was done in similar formations at four sites to confirm the reliability of initial results. All other samples reflect differing lithologies, operating methods, or equipment. The scope of collecting in-situ rock data has been greater than was anticipated originally, because formations encountered in most locations could not be correlated with the existing rock data. Rock specimens or cores have been collected for engineering property tests from 41 formations at 22 sites.

Two shield operations, two RBM, 19 conventional, and 29 TBM operations have been sampled to date. Rock types classified include four Very High, 27 High Strength, nine Medium, six Low, and six Very Low Strength. Early in 1972 a request was received from the Project Officer to increase the volume of samples provided for testing at the Pittsburgh Mining and Safety Research Center (PMSRC) from 2 to 4 cubic feet of minus 2-inch material. Sampling and laboratory procedures were modified to comply with this request.

Muck samples collected are representative of the material as it reaches the transportation system. Muck produced mechanically normally is sampled as it leaves the conveyor which is integral with the machine. Conventional muck is sampled by channeling. Pieces which are too large for practical delivery to a laboratory are measured, and calculated weights in the various size ranges are added to adjust the screen test results. Rock specimens, or rock cores when available, are collected in sizes large enough to permit the preparation of six test specimens approximately 2-1/8 inches in diameter by 4-1/4 inches long.

In the first year of the program, operating data was collected in the detail believed necessary for inclusion of all system components in analysis and selection of transportation subsystems. Preliminary data analysis indicated a need for more precise thrust, torque, and cutter data than was expected for mechanical turneling. With the exception of two types of drag cutter machines, reliable data were collected in the second year on thrust and cutter spacing for all of the TBMs sampled under the program. Net torque could not be determined within the scope of the contract for most of the TBMs observed. To approximate these data, rotation and penetration rates were collected with the same exceptions.

3.3 PHYSICAL TESTING

Published test methods were revolved in detail to ensure that tests performed by commercial laboratories would yield consistent results. The following American Society for Testing and Materials (ASTM) standard methods were selected as specifications in the first year of the program.

C566-67: Total Meisture Content by Drying

C136-67: Sieve or Screen Analysis of Fine and Coarse Aggregates

C117-69: Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing

C29-69: Unit Weight of Aggregate, Loose Weight Determination

C170-50: Compressive Strength of Natural Building Stone

Specifications for the last test procedure were modified to provide for greater accuracy in specimen preparation so that results will be comparable to those reported by other rock property research programs.

Review of the data collected in the first year led to a decision to test rock specimens for deformation moduli in the second year to provide additional data for regression analyses. Following a review of test methods, ASTM Standard C170-50 was replaced by the following procedure, and additional standards were developed to conform with the practices following by U. S. Bureau of Mines research centers in measuring strain.

D2938-71: Unconfined Compressive Strength of Rock Core Specimens

Results of hardness tests by the Shore scleroscope, a laboratory instrument which tests hardness by rebound, were available for only a few of the rock formations sampled. Additional tests by this method were found to be beyond the financial scope of the study. Hardness testing by the Schmidt hammer, a portable device which also tests rebound hardness, is nondestructive and relatively inexpensive and was included in the 1972 program. A hammer was purchased for use in testing tunnel walls and rock specimens.

Standard methods of testing abrasiveness were reviewed to determine the feasibility of collecting these data from tests on muck samples.

The standard ASTM tests were found to measure the resistance of the sample to abrasion, rather than the abrasive effect on other materials. The latter is the property of greater interest in materials handling. A machine designed for such testing was located by the Project Officer at the PMSRC. Tests of retained muck samples were planned for the second half of 1972, but necessary renovation of the equipment could not be completed, and no tests were run.

Modification of the standard screen test procedure was found necessary in testing muck from some low strength rocks. Because the presence of moisture in muck samples affects test results by blinding screens, standard tests require drying prior to screening. Since fine particles adhere to others, washing prior to dry screening is necessary for accurate determination of the percentage of particles finer than 200 mesh. The percentage of fines is an important parameter in hydraulic conveying, and the ASTM test originally selected provided for dry screening following washing. This test was satisfactory for most formations, but not for those which disintegrate when washed. For these an additional screen test at natural moisture content was specified to show the properties of the muck which would be handled by systems other than hydraulic. Natural screen test results are identified and shown as dotted lines on the size distribution curves shown on the individual data sheets. and elsewhere by the notation (N) following the observation number.

Contracts to perform muck tests were negotiated with 18 commercial testing laboratories. Collected samples were delivered for testing and shipment of minus 2-inch fractions to the U. S. Bureau of Mines, PMSRC, for additional tests to be performed at this facility. One set of samples tested commercially was lost in transit to the PMSRC. Tests performed by the PMSRC include a standard suite to determine Atterberg limits, and tests for specific gravity, potential volume change, angles of repose for 1-inch and 10-inch drops, angles of slide and internal friction, apparent cohesion, and bulk density. These tests were run in accordance with procedures described in a paper, "Physical Properties of Bulk Materials," prepared by D. E. Frisque and L. C. Marracini, PMSRC, for a seminar and workshop in December 1970.

Contracts to perform tests on rock specimens were negotiated with five commercial laboratories. Two sets of specimens destroyed in preparation for testing in 1971 were replaced in 1972. Forty-one sets of rock specimens were collected and tested. Stress-strain data were obtained for 24 rocks, including 6 collected in 1971. Stress-strain data for one set of specimens were provided by the Twin Cities Mining

Research Center. All other modulus tests were run by commercial laboratories.

Initial Schmidt hardness tests on walls of tunnels gave results which correlated well with those reported by other researchers on similar rocks. Initial tests on 11 core specimens showed little correlation with field tests or with values obtained from the hardness-compressive strength relationships established by other investigations. Further trials on hand lapped core specimens and a modified cradle indicated that lapping raised test values somewhat nearer those observed in tunnel wall tests. Some variation in values appeared to be associated with core straightness. An inexpensive method of grinding opposite flat planes on cores and rock specimens, developed by the American Standards Testing Laboratories, Los Augeles, California, was found to produce acceptable results with specimens tested on the bed of a hydraulic press. Tests on 33 cores and specimens, averaging 31 readings per formation, were performed by this laboratory and project personnel.

3.4 DATA PROCESSING

A format was developed for computer printout of lithologic, rock, muck, operating, and transport system data. All data have been stored on punch cards and princouts are included as Appendix B. Blank spaces on the printout indicate that data is not available or is not applicable to the section.

Narrative and graphic summaries were prepared to combine these data with descriptions of the excavation systems from which rock and muck samples were taken, and are included as Appendix C. Rock strength classifications are based on uniaxial compressive strength, and conform with those proposed by D. U. Deere, et al, in the "Engineering Classification and Index Properties for Intact Rock," University of Illinois, 1966. These classifications are:

Very High Strength - Greater than 32,000 psi
High Strength - 16,000 to 32,000 psi
Medium Strength - 8,000 to 16,000 psi
Low Strength - 4,000 to 8,000 psi
Very Low Strength - Less than 4,000 psi

Grain size classifications of igneous rocks, from A. Johannsen's "A Descriptive Petrology of Igneous Rocks," 1931, are used as follows:

Very Coarse - Above 3 cm
Coarse - 1 to 3 cm
Medium - 1 to 10 mm
Fine - Belc 1 mm

From J. F. Kemp's "A Handbook of Rocks," 1950, sedimentary rocks of fragmental grain size 2 mm and above are classified as conglomerates, while those below 2 mm in size are classified as sandstones or siltstones.

Symbols used to describe the shape of particles in the sample fractions between screen sizes are the following:

A - Angular S - Subangular P - Platy R - Rounded E - Elongated C - Cubic I - Irregular Sp - Spheroid

The curves show the percentage of the total sample weight passing one screen size and retained on the next. Screen sizes below 1/2 inch were selected to provide openings which become progressively smaller by approximately 50 percent as shown below:

Screen Size #4 #8 #16 #30 #50 #100 #200

Nominal Square 0.187 0.094 0.047 0.023 0.012 0.006 0.003 Openings, Inches

3.5 DEVELOPMENT OF MDN

In accordance with the program plan, analysis of data and development of MDN were preliminary during the first year. As data was collected, test results were reviewed to confirm the validity of the concept. Based on classification by materials handling characteristics, the system as proposed employed seven numbered categories in which to group excavation products by size and size distribution. Numbers were to be assigned in a progression from No. 1 for muck with a relatively large maximum piece size and a predominant distribution in the 1 inch to 200 mesh range, to No. 7, of which the maximum size was relatively small with the predominant distribution minus 50 mesh in size. The concept also recognized that muck characteristics would vary with excavation methods and contemplated modifying the MDN to distinguish between excavation techniques.

Initial field work was scheduled at sites where rock strengths varied over a wide range and which provided examples of shield, machine, and conventional operations. The size distribution curves of the muck from these sites varied distinctly, in general agreement with the criteria, except that the size range of the predominant distribution was somewhat higher than had been inferred.

Resampling at four of the original sites confirmed the distinctive shape of the size distribution curves. Sampling at other sites produced some curves which fit well into the original categories and others which were distinctive enough to suggest establishing additional categories. Using the data available at the end of the first year, curves of similar form were plotted together, and tentative MDN were assigned. Separate composite curves were prepared for muck produced by conventional and machine operations, and assignments were from No. 1 through No. 7 in each broad category, differentiated by the terms "Conventional," "Machine," or "Machine and Shield," and shown as tentative by a "T" prefix.

Refinements of the MDN were considered when additional data had been collected in the second year of the program. Attempts to gather data which would permit subdividing the machine classifications by cutter type had been unsuccessful. Eventually, the concept of a series of MDN for each excavation method was abandoned because of its complexity, the similarity between curves assigned different numbers, and acceptance of the concept that muck samples should be grouped with others of similar characteristics regardless of the excavation method, since the excavation parameters would be introduced in the regression analysis.

When all test data had been received, similar size distribution curves from commercial laboratory muck tests were plotted together in the composite curves shown on Figures 3-1 through 3-7. As discussed under Physical Testing, two sets of distribution curves were obtained for each of nine samples expected to break down during wash screening. Four sets of these curves showed no significant differences and were assigned the same MDN. As shown by the illustrations, the MDN of the others varied with the test method by three or four numbers. For those samples tested by both screening methods, the suffix "W" is used with the observation number to indicate that the sample was washed, and "N" to indicate screening with natural moisture. As shown on the data sheets, all MDN are based on dry screen analysis after washing unless noted by (N) to indicate analysis with natural moisture.

It was planned originally to modify the assigned MDN by point numbers to indicate such bulk material properties as abrasiveness and bulk density. The nature of the regression analysis output, consisting of predicted whole numbers and decimals (residuals) indicating the error of estimate, led to the conclusion that such modifications would be misleading, and this point concept was not developed further. Some consideration was given to assigning point numbers in an order of the percent in one or two predominant size ranges, but time did not permit evaluation of this concept.

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As assigned, MDN indicate materials handling properties as shown by the range of sizes in the summaries which follow. For MDN 1 through 4, the ranges summarized are those of greates: interest to transportation by rail cars, free vehicles, and belt conveyors. For MDN 5 through 7, the ranges are those which may be of interest to any system, but are particularly significant in consideration of hydraulic and pneumatic systems. The maximum and minimum values shown for minus 1/2 inch, minus #8 plus #100, and minus #100 are derived from individual sample analyses and do not represent the sums of high and low values shown on the composite curves in all cases.

Reference to the summaries and the individual size distribution curves will show the relationship between MDN assignments and commercial screen test results. MDN 1 through 4 are differentiated by the percent in the maximum size range. MDN 1 contains more than 20% + 6%, MDN 2 more than 0% and less than 20% + 6%, MDN 3 contains 0% + 6% and more than 0% + 3%, and MDN 4 contains 0% + 3% and more than 0% + 2%. MDN 5 and 6 both contain 0% + 2%, and differ by the concentrations in the -1% + 1/2% and the -1/2% + No. 4 fractions. MDN 6 samples contain 0% + 2% and, with one exception, more than 0% + 1%. MDN 7 samples, again with one exception, contain 0% + 1%. The exceptions, Samples CL-1 and Nast 2, could have been classified differently by one number to meet "nonexception" criteria, but were retained as shown because of the difference in slope of the last curve segment.

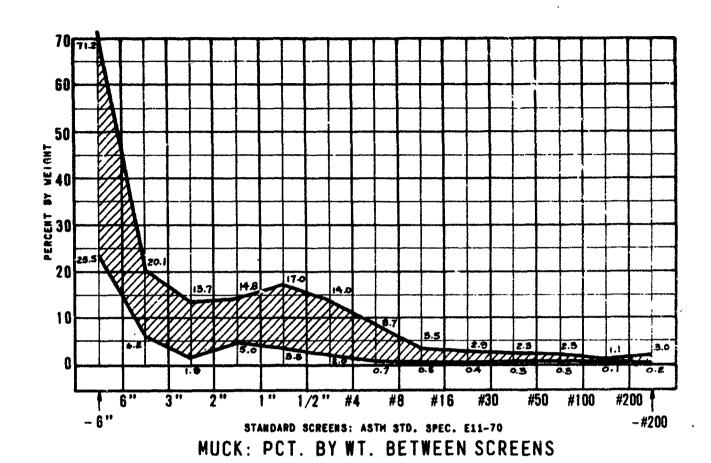
SIZE CHARACTERISTIC SUMMARIES

	RANGE OF SIZE CHARACTERISTICS, MDN 1 THROUGH 4											
	MUCK, SIZE DISTRIBUTION BY WEIGHT AND PERCENT											
MDN	MDN +6" -6" -3" -2" -1" -1/2" -1/2" -#100* Maximum Size Observed											
1.	71.2- 23.5	20.1- 6.2	13.7- 1.9	14.8- 5.0	17.0- 3.8	30.2- 4.7	3.7- 0.5	4'x3'x2'- 18"x12"x10"				
2.	19.1- 4.7	28.9- 6.8	18.2- 1.4	19.3- 6.8	15.7- 10.4	61.6- 8.4	17.4- 0.7	2-1/2'x2-1/2' x12"-8"x8"x4"				
3.	0.0	19.1- 1.5	19.2- 0.9	33.1- 5.8	22,6- 5.9	70.7- 24.9	53.8- 2.0	4'x1-1/2'x4"- 4"x4"x1/2"				
4.	0.0	0.0	8.0- 0.4	26.6- 1.9	31.0- 5.2	87.0- 45.0	42.1- 6.5	3'x14"x8"- 4"x1-1/2" x3/4"				

^{*} Included with -1/2" fraction

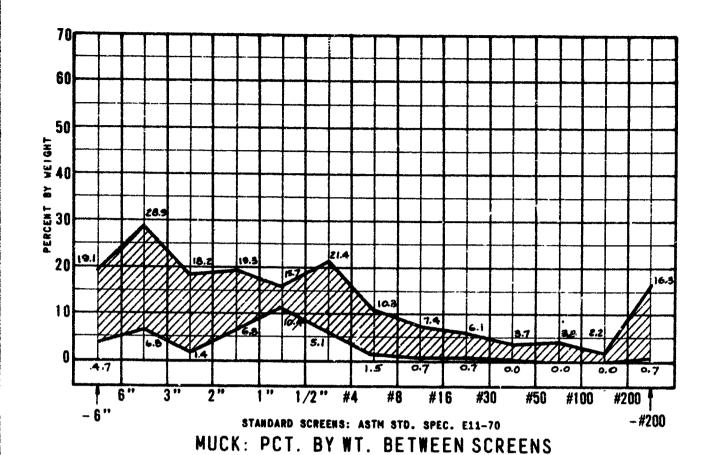
	RANGE OF SIZE CHARACTERISTICS, MDN 5 THROUGH 7											
MDN	+2''	-2" +1"	-1" +1/2"	-1/2" +#4	-#4 +#8	-#8 +#100	-#100	Maximum Size Observed				
5.	0.0	33.8- 2.2	32.7~ 13.3	24.0- 10.6	11.5- 4.3	39.8- 6.9	28.6- 8.1	8"x6"x6"- 2"x1"x1/2"				
6.	0.0	13.0-	16.0- 4.8	37.8- 19.0	18.1-	37.0- 12.4	29.5- 6.0	3'x2'x8"- 1-1/2"x2-1/2" x3/4"				
7.	0.0	0.8- 0.0	11.5-	25.0- 2.0	13.8-2.3	61.0- 36.1	49.2-	18"x10"x4"- 1"x1"x1/2"				

To explain the observation of a large boulder in a pile which produced no +6", +3", or +2" material in the screen analysis, these are nonrepresentative because none were found in the sample population. Observations were noted because maximum size is important in the design of handling systems.



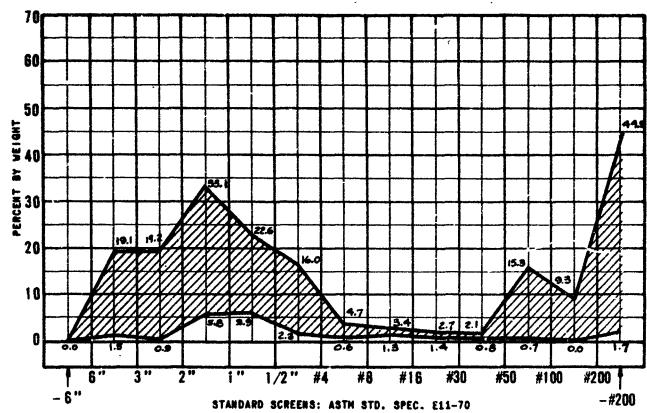
Ident. Obs. Exc Test Percent by Weight Max. Size -#100 ** +6" -6"+3" -3"+2" -2"+1" -1"+3" Observed Symb No * 71.2 $4'x1'x1\frac{1}{2}'$ 39 C 1 8.1 1.9 5.4 4.5 8.9 0.5 ST-1 66.8 13.8 5.9 5.0 0.5 4'x3'x2' LK-1 17 С 1 3.8 4.7 34.1 17.4 10.2 10,6 18.6 2.7 2 2 1 x 1 1 x 6 " LK-3 31 С 1 9.1 27"x18"x12" 13.9 17.0 С 26.3 19.3 13.7 3.7 LK-4 33 9.8 С 49.1 8.7 5.8 14.0 31 x2 x2' LK-2 16.9 5.5 1.8 19 15 С 32.5 11.4 12.0 9.9 9.9 24.3 2.9 28"x18"x12" H-3 CR-1 14.1 10.2 41 С ı 44.7 6.2 8.5 16.3 1.9 30"x14"x12" 27 С 23.5 10.8 14.8 17.0 30.2 2.9 18"x12"x10 SM-l 1 3.7 KM-1 103N М 2 46.7 20.1 8.4 11.0 6.4 7.4 NA 36"x14"x8" 22"x18"x18" HS - 1 43 С 26.3 17.5 9.2 13.2 13.3 20.5 3.5 71.2 20.1 13.7 14.8 17.0 30. 2 3.7 Max. Pct. Summary 1.9 4.7 0.5 Min. Pct. 23.5 6.2 5.0 3.8

FIGURE 3-1
MDN DEVELOPMENT (MDN-1)



Exc Ident. Obs. Test Percent by Weight Max. Size +6" -6"+3" -2"+1" -1"+1 $-\frac{1}{2}$ 11 Symb. No. * ** -3"+2" -#100 Observed GA-1 9 С l 17.9 4.7 12.2 10.3 11.7 21 x2'x12" 43.2 3.7 11-3 57 C 18"x18"x4" 7.8 12.6 11.3 14.4 14.9 39.0 8.9 11 H-1 С 1 14.3 12.7 6.8 13.2 13.6 39.4 31x21x12" 5.6 NAST-5 C 1 14.5 16.2 6.2 12.6 13.7 36.8 2½'x1½'x12" 5.3 C 7.3 11.7 H-2 13 1 18.2 19.3 11.6 31.9 4.4 2'x1\frac{1}{2}'x12" 11-4 59 M 8.2 15.7 17.7 17.0 19.3 8"x8"x4" 22.1 1.5 65 С MSU-2 l 19.1 28.9 17.2 16.0 10.4 0.7 8.4 21"x13"x10" MB-3 37W 1 16.1 17.3 M 2.7 6.8 10.4 46.7 6.9 24"x12"x10" MB-3 37N M 2 15.9 18.2 2.7 7.0 12.8 43.4 1.7 24"x12"x10" LK-7 25 14.0 C 1 13.1 11.2 12.3 15.5 $2\frac{1}{2}$ 'x $2\frac{1}{2}$ 'x12'' 33.9 5.5 35 7.2 MB-1 M 1 9.7 1.4 8.7 11.4 61.6 17.4 2'x1\frac{1}{2}'x8" 101N 10.0 10.0 SF-2 S NA NA NA NA 3'x2'x8" Max. Pct 19.1 28.9 18.2 19.3 15.7 61.6 17.4 Junimary Min. Pct 4.7 6.8 1.4 6.8 10.4 0.7

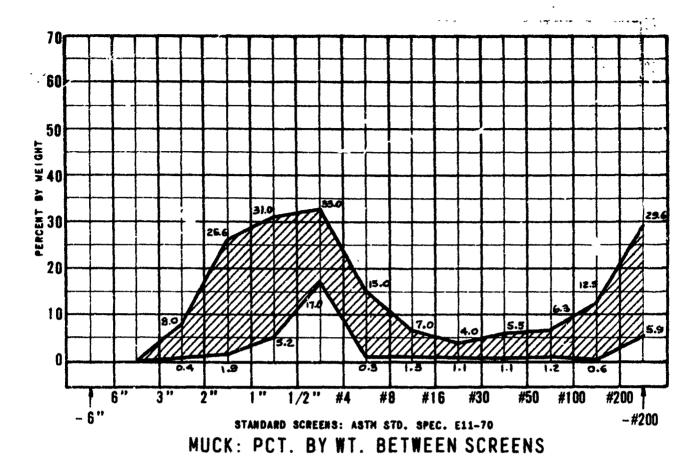
FIGURE 3-2
MDN DEVELOPMENT (MDN-2)



MUCK: PCT. BY WT. BETWEEN SCREENS

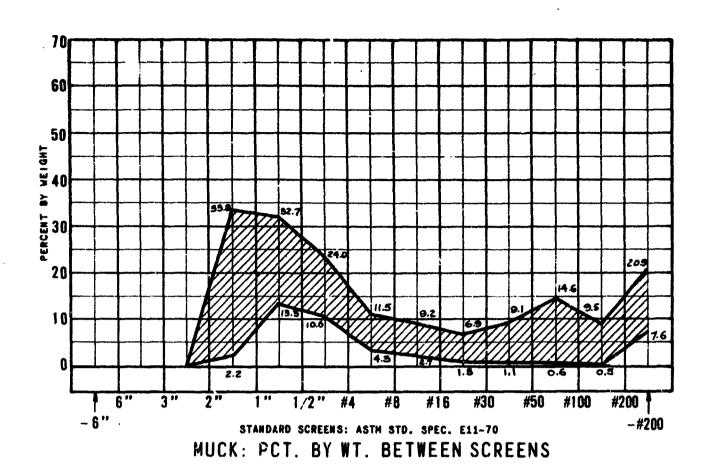
Ident.	Obs.	Exc.	Test		Max. Size						
Symb.	No.	*	**	+6"	-6"+3"	-3"+2"	-2"+1"	$-1"+\frac{1}{2}"$	- 1 11	-#100	Observed
NAV-1	89W	M	1	0	12.1	7.4	6.9	5.9	67.7	53.8	6"x5"x2"
NAV-1	89N	М	2	0	19.1	6.8	23.0	19.0	32.1	NA	6"x5"x2"
MSU-1	63	С	1	0	17.0	12.0	24. 0	18.0	29. 0	2.0	6"x10"x8"
MB-2	51	С	1	0	12.5	19.2	24.5	18.9	24. 9	2.1	4'x1½'x4"
LAY-1	83	М	1	0	7.6	7.5	5.8	12.6	66.5	26.6	4"x4"x ¹ 2"
7-2	55	М	1	0	1.5	0.9	33.1	22.6	41.9	14.5	3"x9"x1"
WNG-2	97N	С	2	0	8.7	5.4	7.9	7. 3	70.7	NA	18"x10"x4"
WNG-1	95N	М	2	0	6.9	3, 3	15.7	11.7	62.4	NA	14"x4"x4"
Sum	mary		x. Pct.	0	19.1	19.2	33 <u>1</u> 5.8	22. 6 5. 9	70.7 24.9	53.8 2.0	

FIGURE 3-3
MDN DEVELOPMENT (MDN-3)



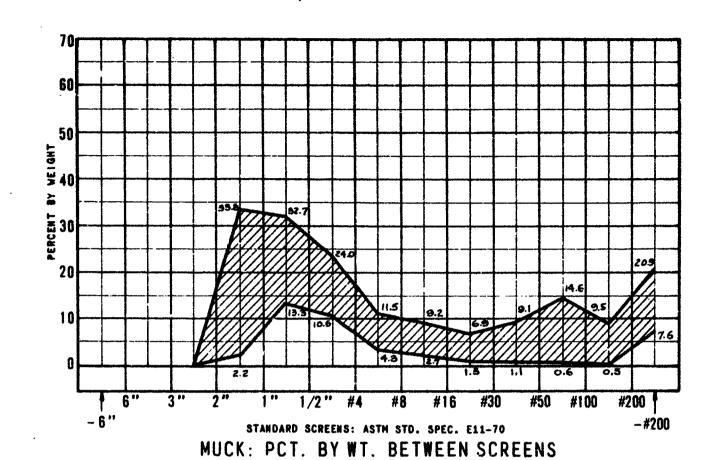
Ident.	Obs.	Exc.	Test		Max. Size						
Symb.	No.	*	**	+6"	-6"+3"	-3"+2"	-2"+1"	-1"+1"	<u>}</u> 11	-#100	Observed
LAW-2	67	М	1	0	0	3.0	25.0	18.0	54.0	8.7	3!'x2''x2''
LAW-3	69	М	1	0	0	4.3	25.9	19.6	50.2	11.0	3"x21"x1"
LAW-4	71	M	i	0	0	5.0	18.3	18.3	58.4	16.3	3½"x2½"x3/4
RO-1	93	М	1	0	0	2.0	9.0	12.0	77.0	14.0	$4''x1\frac{1}{2}''x3/4''$
KM-1	103W	М	1	0	0	5.9	1.9	5. 2	87.0	42.1	3'x14"x8"
72-1	61W	М	1	0	0	4.0	18.8	31.0	45.2	6.5	$12'' \times 7'' \times 1\frac{1}{2}''$
72-1	61N	М	2	0	0	8.0	24.0	23.0	45.0	NA	$12'' \times 7'' \times 1\frac{1}{2}''$
EVG-1	79	М	1	0	0	3.2	26.6	22.1	48.1	11.1	3"x6"x3/4"
EVG-2	81	М	1	0	0	2.2	24.4	26.7	46.7	12.4	$4\frac{1}{2}$ "x2 $\frac{1}{2}$ "x1 $\frac{1}{2}$ "
NAV-2	91N	M	2	0	0	0.4	12.6	19.6	67.4	NA	5"x2"x1"
		Ma	x, Pct.	0	0	8.0	26.6	31.0	87.0	42.1	
Summary Mir		n. Pct.	0	0	0.4	1.9	5.2	45.0	6.5	<u> </u>	

FIGURE 3-4
MDN DEVELOPMENT (MDN-4)



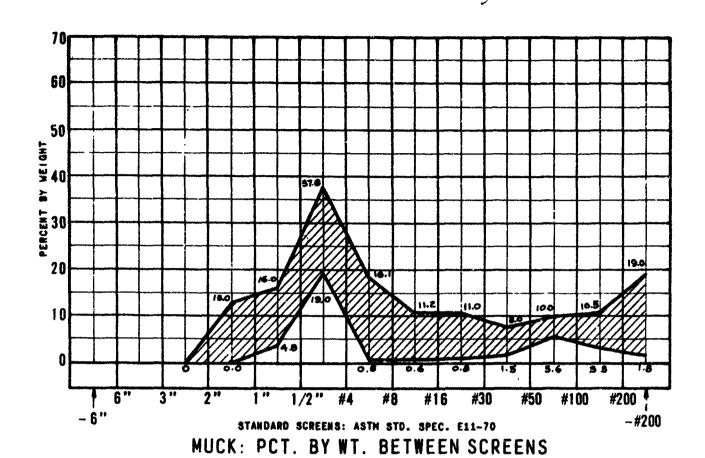
Ident.	Obs.	Exc.	Test			Perc	ent by W	eight			Max. Size
Symb.	No.	*	赤本	+2"	-2"+1"	$-1"+\frac{1}{2}"$	$-\frac{1}{2}$ " + 4#	-#4+#8	-#8+#100	-#100	Observed
5-1	53	N,	1	0	33.8	20.9	15.5	4.4	8.6	16.8	2½"x8"x3/4"
MIL-1	73	М	1	0	14.5	28.0	24.0	8. 2	17.2	8. 1	2"x1"x ¹ "
MIL-2	75	М	1	0	9.2	24.7	22.8	11.5	15.6	16.2	3"x2"x ¹ 2"
QL-1	49	М	1	0	7.6	17.0	13.4	4.5	28.9	28. 6	2"x1"x ¹ "
MIL-3	77	М	1	0	25.4	32.7	17.4	4.3	6.9	13.3	4"x1-3/4"x1/2
LAY-2	85	М	1	0	6.0	30.0	23.0	8.0	16.0	17.0	8''x6''x6''
NY-I	45	М	1	0	3.5	21.9	12 3	6.6	32.0	23.7	$2^{11} \times 2^{\frac{1}{2}} \times 3/4^{1}$
NY-2	47	М	1	J	2.2	13.3	10.6	5.6	39.8	28.5	2"x1-3/4"x
		Ma	x. Pct.	0	33.8	32.7	24.0	11.5	39.8	28.6	
Sum	mary	Mir	ı, Pct.	0	2.2	13.3	10.6	4.3	6.9	8.1	1

FIGURE 3-5
MDN DEVELOPMENT (MDN-5)



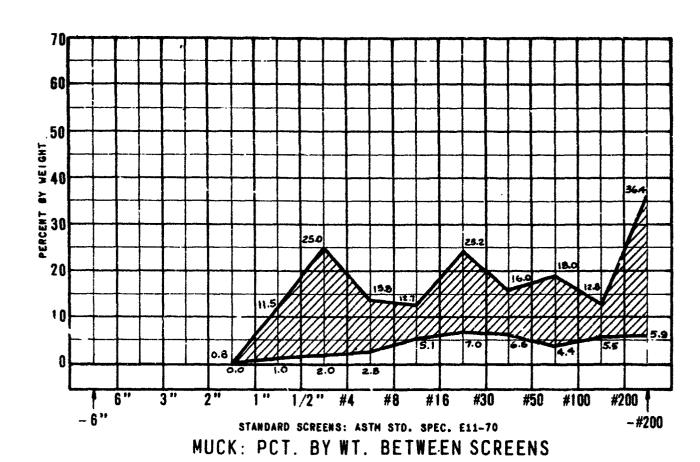
Ident. Obs. Exc. Test Percent by Weight Max. Size $-\frac{1}{2}$ "+4# * ** -1"+1" -#4+#8 -#8+#100 -#100 Symb. No. +2" -2"+1" Observed 5-1 53 M 1 0 33.8 20.9 15.5 8.6 16.8 $2\frac{1}{2}$ "x8"x3/4" 4.4 73 28.0 $2''x1''x^{\frac{1}{2}''}$ MIL-1 M 1 0 14.5 24.0 8. 2 17.2 8.1 MIL-2 0 75 M 1 9.2 24.7 22.8 11.5 15. 6 16.2 3"x2"x½" QL-1 49 1 0 7.6 M 17.0 13.4 28.9 28.6 2"x1"x½" 4.5 MIL-3 77 0 25.4 4.3 $4'' \times 1 - 3/4'' \times \frac{1}{2}'$ М 32.7 17.4 6.9 13.3 LAY-2 0 85 M 6.0 30.0 23.0 8.0 16.0 17.0 8"x6"x6" 0 NY-I 45 M 1 3.5 21.9 23.7 2"x2\frac{1}{2}"x3/4" 12.3 6.6 32.0 NY-2 47 M 1 0 2.2 13.3 10.6 28.5 $2''x1-3/4''x\frac{1}{2}''$ 5.6 39.8 Max. Pct. 0 33.8 32,7 24.0 11.5 39.8 28.6 Summary Min. Pct. 0 2.2 13.3 10.6 4.3 6.9 8.1

FIGURE 3-5
MDN DEVELOPMENT (MDN-5)



Ident.	Obs.	Exc.	Test			Perc	ent by W	eight			Max. Size
Symb.	No.	*	**	+2"	-2"+1"	$-1^{11}+\frac{1}{2}^{11}$	-11+#4	-#4+#8	-#8+#100	-#100	Observed
CL-1	29	М	1	0	0.0	4.8	37.8	18.1	32.1	7.2	1½"x2½"x3/4
SF-2	101W	S	1	0	8.6	14.4	34.6	0.5	12.4	29.5	3'x2'x8''
LK-5	21	М	1	0	13.0	14.0	20.0	7.0	30.0	16.0	$2\frac{1}{2}$ "x4"x3/4"
LK-6	23	М	1	0	1.0	9.0	19.0	12.0	37.0	22.0	$2'' \times 3\frac{1}{2}'' \times 1\frac{1}{4}''$
CNT-1	87N	М	2	0	7.0	16.0	28.0	11.0	32.0	6.0	3"x2"x1 ½"
CNT-1	87W	M	1	0	4.0	15.0	25.0	10.0	21.0	25.0	3"x2"x1 ½"
		Ma	x. Pct.	0	13.0	16.0	37.8	18.1	37.0	29.5	
Sun	nnary	Mir	ı. Pct.	0	0.0	4.8	19.0	0.5	12.4	6 0	

FIGURE 3-6
MDN DEVELOPMENT (MDN-6)



Ident. Obs. Exc **Test** Percent by Weight Max. Size -#100 No. * ** +2" -2"+1" $-1^{11}+\frac{1}{2}^{11}$ -- 14+#8 -#8+#100 Observed Symb 5"x2"x1" NAV-2 91 W 1 0 0 1.3 2.5 2.3 57.7 36.2 М 95W 5.0 59.0 33.0 14"x4"x4" WNG-М 1 0 0 1.0 2.0 1 0 0 2.2 4.5 6.1 38.0 49.2 5"x4"x3" SF-1 99 S 4.0 WNG-2 97W С ļ 0 2.0 5.0 61.0 28.0 18"x10"x4" 7 0 0 11.5 20.6 13.6 42.6 11.7 1 2 "x1 "x 2 " VAST-4 M 1 12.5 45.1 $1''x3/4''x\frac{1}{2}''$ NAST-1 M 1 0 0 2.2 14.9 25.3 NAST-2 М 1 0 0.8 8.0 25.0 13.8 36.1 16.3 1"x1"x½" Max. Pct. 0 0.8 11.5 25.0 13.8 61.0 49.2 Summary 2.3 36.1 0 1.0 2.0 11.7

FIGURE 3-7
MDN DEVELOPMENT (MDN-7)

3.6 DATA ANALYSIS

During the first year of the program, an algorithm was developed to correlate those bulk properties of the fragmented material represented by MDN with parameters representing rock properties and excavation methods. The quantitative relationship sought was a predictor equation, obtained by multiple regression of the physical property and operating data from tests and observations. A discussion of this technique is included in Appendix D.

Parameters available for preliminary analysis with the first year's data included uniaxial compressive strength (CSTR), rock quality designation (RQD), dry unit weight (DUW), and water occurrence. To avoid reducing data derivatives to extremely small values, rocks with compressive strengths of less than 1K psi were assigned arbitrary strengths of 1. Rock classifications (CLASS) were quantified as Igneous = 1, Metamorphic = 2, and Sedimentary = 3. Water occurrence was considered a rock property, and was quantified as 1. = Dry, 2. = Minor to Moderate, and 3. = Wet. The construction of the dummy variable used for water occurrence is justified by the relative volumes represented. A physical property justification for the order and magnitude of the number assignment to the CLASS variable is indicated by the 1 to 1.17 ratio of the differences between average compressive strength values as listed in Table 5.1, page 57, of I. W. Farmer's "Engineering Properties of Rocks," 1968.

Schmidt hardness values (H) were converted Shore values, where available, or inferred from data published by D. U. Deere, et al., in the "Engineering Classification and Index Properties for Intact Rock" referenced above. Kerf spacing appeared to be an important TBM characteristic. Average dimensions were available for disc cutter and some drag cutter machines. For roller cutters for which no kerf pattern was apparent, values were obtained by dividing the body spacing by the number of buttons on or adjacent to a line along the face of the cutter and parallel to the axis of rotation. No kerf spacing was available for Alpine and Atlas-Copco TBMs. Net thrust values per square foot of face area (T) were available for TBMs with the same exceptions. No appropriate operating parameters were available for the Alpine and Atlas-Copco machines or for the shield operations sampled. Parameters peculiar to conventional operations, face area per drill hole (A/H), and explosives per cubic yard excavated (PF) were calculated from collected data.

An initial analysis using rock properties alone led to a predictor equation for which the accuracy, described by the multiple correlation coefficient, was 72 percent. This was expected since operating parameters were not included. Seventeen sets of data, combining rock

properties with machine operating parameters, were analyzed by stepwise regression which indicated a prediction accuracy of slightly more than 90 percent. Ten sets of rock and conventional operating data were analyzed, with an indicated accuracy of over 99 percent. Since the number of observations was nearly equal to the number of variables, it was noted that this level of accuracy probably would not be maintained when more data became available.

The contract for the second year's program provided for collecting the same data on new samples as well as some additional data. One proposed parameter, abrasiveness, could not be determined because the test equipment required renovation which could not be completed in time for use. Schmidt hardness (H) was determined by laboratory tests on specimens from the twenty formations sampled during the year, and on nine specimens from sites previously sampled. Values used for others were inferred from tests of similar rocks, from data published by D. U. Deere, et al., in the "Engineering Classification and Index Properties for Intact Rock," or were assigned minimum values for rocks so weak that no test data could be obtained. Young's Modulus (ET) and Poisson's Ratio (P. Ratio) were determined by commercial laboratory tests on 22 sets of in cimens, and for 1 set by tests performed by the Twin Cities Mining Research Laboratory of the U. S. Bureau of Mines. Other values were inferred or assigned as those for Schmidt hardness.

Since water occurrence in a tunnel can be controlled to a degree, it was considered more reasonable to treat this factor as a characteristic of the tunnel system, rather than a rock property. In the final analyses, water occurrence was quantified as in the preliminary, but described the condition in the tunnel at the time of sampling rather than that in a drill hole during exploration. In the regression matrix, the test methods which produced different MDN from the same sample were quantified as 1 = Dry screened after washing, and 2 = Screened with natural moisture; the suffix "W" was used with the observation number to indicate that the sample was washed, and "N" to indicate screening with natural moisture.

Values used for TBM kerf spacing and net thrust were derived as for the preliminary analysis, and rotation speeds (RPM) and penetration rates in feet per machine operating hour were collected during field observations or from tunnel records. No appropriate operating parameters could be developed for the Alpine and Atlas-Copco machines or for the shield operations sampled. Parameters peculiar to conventional operations, face area per drill hole (A/H), and explosives per cubic yard excavated (PF) were calculated from collected data.

As independent variables for prediction of muck materials handling properties, compressive strength, hardness, and the modulus of elasticity agone are believed inappropriate because they can be determined only by tests on intact specimens. These normally do not represent rock formations, which seldom exist without some discontinuity which affects the characteristics of excavated muck. The RQD, a function of the fractures, joints, and other planes of weakness in the rock mass, when used in the preliminary analysis as one independent variable, was among the less important. In the final analysis, RQD was used in combination with rock strength, hardness, and the elastic modulus modified by the factor 1×10^{-5} to produce a usable number (HCERQD). Other rock properties, water occurrence, and the test method were used as individual variables.

It has been suggested that better results might be developed by using an alternate method of dummy variable construction for rock classification (CLASS). Instead of assigning the three numbers 1, 2, and 3, the variable description could indicate merely class membership or nonmembership as in the following example:

Variable 1	Variable 2	Interpretation
1	0	Igneous
0	1	Metamorphic
0	0	Sedimentary

Testing the effectiveness of this construction is beyond the scope of the program, but is recommended for inclusion in future research.

Reliable data was collected on the cutter head rotation speed of the TBMs and on the thrust, kerf spacing, and penetration rates of all TBMs except the Alpine and Atlas-Copco. Thrust values were modified to thrust per square foot of face area in the TBM analyses. Net torque could be developed for only a few of the TBMs within the project scope. It appeared logical to combine the rotation speed with an area or volume dimension to equalize the effect of excavation size. Since volume per hour as a measurement of energy expended is related to energy input, and rotation speed is a (reciprocal) factor in the basic torque equation, a combination variable of cubic feet of excavation per hour and RPM (CF/RPM) was used in the final regression.

The preliminary analysis used the program known as STEPWISE which is available from the IBM/367 time-sharing system. It had the disadvantage of having a limit of ten variables, and with more extensive analysis, the output features were limited. With more data and more

analysis, the program BMD02R was used. This program is one of the Biomedical Computer programs, available in a batch processing mode from the CDC 6600 Cybernet System. Variable significance testing is integral with these programs, as shown by the order in which the variables were entered and by the regression coefficients (Multiple R) on Figures 3-10 and 3-11 and the tabulation on page 3-22. Further discussion of both programs is included in Appendix D.

Twenty-seven sets of data were analyzed for machine operations using the values tabulated in Figure 3-8. Seven sets of data were not included because operating data was not complete. Results of the analysis shown in Figure 3-9 indicate an accuracy of about 82 percent with a standard error of 0.8106. A review of the data sets which resulted in residuals (errors in prediction) of more than one might reveal valid reasons for modification, but is beyond the scope of the current program.

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Twenty sets of data with the values shown in Figure 3-10 were analyzed for conventional operations, with the output shown in Figure 3-11. The indicated accuracy is a little over 95 percent with a standard error of 0.5189. The residuals are generally smaller than those from the machine analysis; the number of variables is large in relation to the number of observations, and the indicated accuracy of prediction may be reduced by the inclusion of more data sets.

All of the data in each category was correlated to indicate the relative importance of the individual variables and eight additional correlations were run with each matrix to test the significance of various combinations of variables. The final correlations illustrated were run with the individual and combined variables which had the greatest effect on the regression coefficient in the trial runs.

The data sets shown in Figure 3-12 represent seven samples from machine and shield operations for which no operating parameters have been developed. Correlation using all variables showed an accuracy (nearly 100 percent) which is meaningless because of the small number of observations. For this reason a summarized computer output of the coefficients for the individual variables and of the residuals is not shown. However, the order of importance of the variables is indicated by the following table, which summarizes results of the regression:

Step No.	Variable No.	Variable	Multiple R
1	9	Water	0.6345
2 .	10	Test	0.9013
3	3	Hardness	0. 94 75
4	2	DUW	0.9830
5	6	P. Ratio	0.9913
6	5	ET	0.9918
7	8	Class	0.9964

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CONVENTIONAL DATA ANALYSIS OUTPUT, IJ

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SHIELD AND MISC. MACHINE EXCAVATION PARAMETERS

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SHIELD AND MISCELLANEOUS MACHINE MATRIX

3.7 TRANSPORT SYSTEM AND EQUIPMENT SELECTION

3.7.1 MDN and Bulk Properties Prediction

In application, exploration and test results from the site of a future tunnel would be substituted for the rock variables in the predictor equation, with quantified input on expected water occurrence and the characteristics of the proposed excavation subsystem. When sampling shows that the formation will disintegrate substantially when washed, two data sets would be used, one with a value of 1 as the TEST parameter and one with a value of 2. When two MDN are derived from sets of data which differ only in the TEST parameter, the lower number predicted will apply to muck handled in the natural state, and the higher to muck which has been processed by washing, as in preparation for hydraulic conveying.

Within the ranges shown on the summaries in Section 3.5, the predicted MDN will indicate the gross bulk handling properties of the resultant muck. More detailed inferences can be drawn by reference to the data sheets corresponding to the individual observations listed on Figures 3-1 through 3-7, selecting the properties of the formation which matches most nearly the rock, tunnel, and operating characteristics used in the prediction.

3.7.2 <u>Use of MDN</u>

Obviously, from the (statistically) small volume of data available at this stage of the program, predictions can be made for only a small proportion of all the possible combinations of rock, tunnel, and operation variables. Caution in application of the data which is available is suggested to prevent overconfidence in the accuracy of prediction. The "correlation coefficient" at any level indicates only the probability of deriving an MDN closer to the correct number than to any other. Much more data is required, and many predictions must be verified before the MDN concept can become a reliable technique suitable for general application. Nevertheless, with large infusions of judgment, the data and methods so far developed can be valuable tools within their obvious limitations.

Having predicted an MDN, broad selections from the available systems may be made from the following taula.

TRANSPORT SYSTEM CAPABILITY													
Transport	MDN ·												
System	1	2	3	4	5	6	7						
Conventional Rail	Yes	Yes	Yes	Yes	Yes	Yes	Yes						
Side Rail	*	*	*	*	*	*	*						
Free Vehicles	(3)	(3)	Yes	Yes	Yes	(4)	(4)						
Belt Conveyors	(1)	(1)	(2)	(2)	(2)	(2)	(2)						
Hydraulic Pipeline	No	No	(5)	(5)	Yes	Yes	Yes						
Pneumatic Pipeline	No	No	No	*	*	*	*						

- * Possible, technology not fully developed.
- (1) Excessive width, wear, and damage.
- (2) Excessive fines buildup probable in some formations.
- (3) Excessive tire wear probable.
- (4) Excessive roadbed maintenance probable in some formations.
- (5) Practical for muck with less than 10 percent plus 1 inch.

Those systems noted by an asterisk have potential capability which has not been demonstrated in practice. The basis of other notations is discussed in the following examples of MDN applications which are provided in the detail consistent with the scope of the program.

3.7.3 Example 1: Hydraulic Pipeline Feasibility

Hydraulic conveying is a proven method of long distance horizontal and/or vertical slurry transport. Most industrial applications handle material minus 6 mesh in size. Those systems which handle solids in the plus 1/2 inch minus 8 inch size operate in the plus 500 tph capacity range through centrifugal pumps which are so large (16 inches x 40-1/2 inches typical) that use in any but the larger tunnels would result in serious congestion in the near face area. Lock feeders have

demonstrated capability to handle limestone, mine refuse, and coal, 90 to 95 percent plus 1/2 inch in size, with 19 to 25 percent in the minus 2 inch plus 1-1/2 inch range, but the feeder size limits their application also to relatively large tunnels. Centrifugal pumps which will handle minus 1 inch material in the volume produced by current TBM advances are readily available in sizes which can be used in tunnels over 9 feet in diameter, while leaving adequate space for supply and support activities. Classification of hydraulic conveying as a proven tunnel technique is based upon a trial in a Colorado tunnel in which the system was demonstrated to perform well within design capacity.

Tunneling history suggests that an assumption of completely uniform characteristics is unrealistic for most rock formations. The design of an hydraulic system, lacking concrete evidence that no loose ground will be encountered, must incorporate a means of scalping off any material larger than the maximum for which the system is designed, and a means of disposal of this oversize. Assuming that this provision has been made, the limit of hydraulic systems' capabilities used in this study has been set at 10 percent plus 1 inch as indicated by Note (5) in the Transport Capability Table, and by notations on the individual raw data sheets. The basis for this limitation is the judgment of the investigators of the amount of oversize which could be handled by a supplemental haulage system without serious interference with other activities.

The following is a generalized actual case history to illustrate a practical application of MDN and MDN study data. A contractor driving a 16,000-foot, hard rock, water tunnel is using a TBM and conventional rail haulage in the first 9,000-foot section, 9 feet 9 inches in diameter and +0.25 percent in grade. This section is roughly parallel to and on the same elevation as a side hill access road to the outlet portal and the muck disposal area. It will intersect a cross tunnel (adit) at the p/t of the second section. The adit, which is 800 feet long, will provide an outlet to a portal on the access road about 2 miles from the muck disposal area.

Job time can be reduced by lining the first tunnel section and completing concrete structures at the main tunnel portal while the second main tunnel section is being driven. Rail muck haulage would interfere with lining, and the rotary car dump must be removed before construction at the main portal can begin; alternates to rail haulage through the first section for muck from the second section are being considered.

Rock and muck samples are available from the TBM output at three locations in the main tunnel, and from a conventional round at the inby end of the adit. The machine samples have been classified as MDN 7, from the data shown for Nast 1, 2, and 4 on Figure 3-7. Rock properties of the conventional sample GA-1 are shown on Figure 3-10. No disintegration was noted after 24 hours of immersion; the TEST parameter is 1. An advance rate of 3 feet per hour is expected at 8.5 RPM, with a kerf spacing of 0.10 feet and a thrust of 6.0 K pounds/square foot. The predictor equation (Figure 3-9) is:

MDN = $18.312 - DUW \times 0.047 + HCERQD \times 10^{-5} \times 0.011$

- CLASS \times 0.688 TEST \times 1.934 CF/RPM \times 0.004
- THRUST x 0.119 KERF x 5.613.

Substituting the independent variables from Figure 3-10:

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MDN =
$$18.312 - 161 \times 0.047 + (42 \times 35 \times 6.40 \times 96 \times 10^{-5} \times 0.011)$$

- $-1 \times 0.688 1 \times 1.934 (76 \times 3.0/8.5) \times 0.004$
- $-6.0 \times 0.119 0.10 \times 5.613$
- = 18.312 7.567 + 0.099 0.688 1.934 0.107
 - -0.714 0.561
 - = 6.84 which closely approaches the assigned MDN of the three Nast samples.

Reference to the Capability Table indicates that a choice of an alternate to rail haulage is between free vehicles, belt conveyors, and hydraulic conveying. Free vehicles were believed impractical for an average round trip of 7,600 feet in a tunnel in which passing room is less than 9 feet. A belt conveyor design (by others) was considered too expensive, and investigation of an hydraulic pipeline was initiated.

Methods of calculating critical velocities, selecting pipe size and operating velocities, and calculating power requirements developed by many researchers, have been summarized by the Colorado School of Mines Research Foundation in a publication, "The Transportation of Solids in Steel Pipes," 1963 (Reference 1). These methods were used with MDN data in a feasibility study of an hydraulic system.

As shown in detail in Appendix B, the first data required for hydraulic design are the size and size distribution of the muck. In this case, the data are available in Figure 3-7. In preconstruction planning for another site, the same data would be inferred by reference to the individual data sheets for the samples from which MDN 7 was developed. Inspection shows that only Nast 1, 2, and 4 can be representative since the others are all low strength rocks of another class.

Although a method involving evaluation of the head loss produced by each size fraction is considered somewhat more precise, calculation of a single mean-particle size is appropriate for a preliminary calculation. This size was calculated using the size distribution curve for Nast 4 (as the worst case) by taking the average size of the openings in each consecutive pair of screens as a multiplier for the percent of the total retained on the smaller of each pair and dividing the total by 100. The result is 0.198 inch.

Critical velocity is a function of a constant (varying from 0.3 to 1.5 with particle size and solids concentration), the mixture concentration by volume (C_v), the pipe size (D), and the specific gravity (S) of the solid. An average S of 2.55 was calculated from MDN data for Nast 1, 2, and 4, and GA-1. Critical velocities were calculated for two pipe sizes, after determining the constant from the Durand function curves and calculating C_v from concentrations by weight (C_{vv}) as described in Reference 1:

3-Inch Pipe, V _{CR}	7.03 ft/sec
4-Inch Pipe, VCR	8.05 ft/sec

Operating velocity (V_T) is a function of flow rate and pipe cross section. These were calculated for both pipe sizes and concentrations:

Description	30 Percent C _W	40 Percent C _W	
3-Inch Pipe, V _T	8.84 ft/sec	6.23 ft/sec	
4-Inch Pipe, V _T	5.13 ft/sec	3.61 ft/sec	

These calculations indicate that the 3-inch pipe carrying the 30 percent C_W slurry can be used, maintaining the operating velocity above the critical. The flow rate corresponds to 204 gpm.

To determine power requirements, the head loss of clear water is taken from standard tables, a Reynolds number is calculated, a drag coefficient is taken from the standard Reynolds number chart, and the slurry head loss (i_m) is calculated. For the 3-inch pipe at 30 percent Cw, the calculated head loss is 42.15 feet per 100 feet of pipe. This loss is partially compensated by the tunnel grade, 0.25 percent, for an effective head loss of 41.90 feet per 100 feet. For the average distance of 16,000 feet/2 = 8,000 feet plus 500 feet, (added for a distance from the portal to the settling sump), the average head loss becomes 85 x 41.9 = 3,562 feet, and the average hp, based on a 40 percent pump efficiency, 564. The maximum hp is $165/85 \times 564 = 1,094$, corresponding to a maximum head loss of 6,914 feet.

Although there was an existing pipeline in the tunnel which could have been used as a return waterline, the cost estimate for a system to advance with the TBM was on the order of \$200,000, without provision for power transmission. In comparison with an estimated operating advantage of about \$30,000, the concept was not attractive to the contractor.

3.7.4 Example 2: Free Vehicle Application

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The 800-foot adit referenced in Example 1 will be driven at a 10 foot x 10 foot cross section at any time during the life of the contract. Selection of excavation and haulage systems and equipment is necessary for advance procurement.

Core samples and drill logs from a vertical hole at the intersection elevation provide the following data:

Lithology: Igneous, Biotitic Granite,
Fine Grained

Dry Unit Weight (DUW): 161

Schmidt Hardness (H): 42

Compressive Strength (CSTR): 35

Young's Modulus (ET) 6.40

Poisson Ratio (P Ratio):

0.30

RQD:

96 Percent

Rock Class:

1 (Igneous)

Water Occurrence:

1 (Minor)

Immersion of a sample resulted in no disintegration; the TEST variable is 1.

Conventional excavation has broken similar rock with 50 holes (A/H = 2.0) and a powder factor (PF) of 6.1 pounds per cubic yard. A basic decision has been made not to drive the cross tunnel with the TBM because the (side) gripper design makes collaring a branch from an existing tunnel impractical, and the rock at the side hill portal is weathered and unstable for an indeterminate distance, which might further complicate TBM operation.

The MDN of the muck from conventional excavation in this formation is calculated by substituting the variables in the predictor equation (Figure 3-11):

Substituting the rock and operating variables:

MDN =
$$17.958 - (161 \times 0.094) - (42 \times 35 \times 6.4 \times 96 \times 0.097 \times 10^{-5}) + (0.30 \times 4.853) + (1 \times 1.113)$$

+ $(2 \times 0.988) - (1 \times 3.798) - (6.1 \times 0.083)$
= $17.958 - 15.134 - 0.875 + 1.456 + 1.113$
+ $1.976 - 3.798 - 0.506$
= 2.19 , for which the MDN is 2.

The Capability Table (page 3-28) shows that rail, free vehicles, or belt conveyors are suitable systems for MDN 2, and calls attention to the probability of excessive tire wear with free vehicles, and to the excessive width, wear, and damage probable with belt conveyors. Figure 3-2 shows test results of seven conventionally excavated samples with a maximum block size range from 21 inches to 3 feet, and a range of plus 3-inch material from 19 to 48 percent. Conveyor design standards, requiring a belt width of 3 to 4 times the maximum block size, indicate a minimum width of 63 inches to 84 inches. The nominal capacity range of a 60-inch belt is from 600 to 1,000 tons per hour, and the maximum tonnage from this heading will not be greater than 70 tph. This removes the conveyor concept from further consideration.

The estimated completion time of the 800-foot tunnel section is 120 shifts, which may be scheduled during any part of the contract period. The past history of TBMs in strong rock (the main tunnel) predicts several unscheduled delays of days' to weeks' duration. A sound strategy appears to provide for completing the portal and the weathered section of the adit early in the contract, and to drive the remainder during main tunnel downtime. A rubber-tired load-haul-dump unit is a logical choice for mucking and haulage to the portal. The haulage distance is well within the range of this equipment, such a unit will be necessary for muck removal from the main tunnel dumping point, and will not be in critical demand during TBM shutdowns.

The unit can move easily from portal to portal, while a locomotive would require a crane and a lowboy. No car dump would be necessary, and the muck from one round could be stocked at the portal for truck loading during the drilling cycle. Choice of the best equipment for this application can be made from any standard line which provides safe clearance from tunnel ribs and the back, and a diesel engine with an approved exhaust scrubber. Many rigs are available with these specifications in the 2 to 3 cy class, and the final choice would be made of one with a bucket adapted to mount 2 or 3 heavy drifters to serve as a jumbo during drilling cycles. Excessive tire wear can be avoided by minimal fly rock clean up with the LHD bucket, and by the use of chain protectors if this becomes necessary.

3.7.5 Example 3: Belt Conveyors

Note (1) concerning belt conveyor applications in the Transport System Capability Table is illustrated by the excessive width required for an MDN 2 considered in Example 2. Note (2) shown in the table for other MDN has been applied in the data sheets to muck with concentrations of more than 12.5 percent in the minus 100 mesh size range, a limitation based on field observations by the investigators.

To illustrate an MDN application to the selection of a belt conveyor haulage system, data from one of the tunnel sites sampled has been generalized to a 5,000-foot TBM operation in a frong sandstone, diameter 18 feet, grade plus 17 percent. Physical property data includes:

DUW: 166

Hardness: 37

Compressive Strength: 22 K psi

Young's Modulus: 6.00

RQD: 80 Percent

Rock Class (Sedimentary): 3

Immersion Results: No Disintegration

TEST Variable: 1

A machine penetration rate of 6 feet per hour is anticipated with 4.5 RPM, 3.7 K pounds per square foot thrust, and a 0.20-foot kerf spacing.

From Figure 3-9, the predictor equation is:

Substituting the variables

MDN =
$$18.312 - 166 \times 0.047 + (37 \times 22 \times 6.0 \times 80 \times 10^{-5})$$

 $\times 0.011 - 3 \times 0.688 - 1 \times 1.934 - (257 \times 6/4.5)$
 $\times 0.004 - 3.7 \times 0.119 - 0.20 \times 5.613$

= 18.312 - 7.802 + 0.043 - 2.064 - 1.934 - 1.371

= 3.62

- 0.440 - 1.123

With this result, reference to the data sheets is necessary.
Figure 3-8 lists 11 samples with MDN 3 or 4 in Rock Class 3. Of these, four are dissimilar in rock properties and excavation parameters.
The muck characteristics of the remaining seven are shown below, and are summarized in a "worst case."

1d	ldent.	MUCK			Max. Block	DUW	DUW	Angle/ Repose	%	
MDN No.		Size and Distribution				Size	Loose	Solid	10"	Moist. Nat.
		-6"+3"	-3"+1"	-1+100	-100	(In.)	(Lbs.)	(Lbs.)	Drop	
3	7-2	1.5	34.0	50.0	14.5	9	90	166	31°	4.0
4	Law-2	0	28.0	63.3	8.7	3	92	161	38°	7.2
4	Law-3	0	30.2	58.8	11,0	3	93	161	40°	5.5
4	Law-4	0	23.3	60.4	16.3	3-1/2	80	157	34°	7.9
4	Evg-1	0	29.8	59.1	11.1	6	94	168	31°	3.8
4	Evg-2	0	26.6	61.0	12.4	4-1/2	94	170	34°	2.3
4	72-1(W)	0	22.8	70.7	6.5	12	86	168	32°	1.5
4	72-1(N)	0	32.0	NA.	NA	12	86	168	32°	1.5
Wor	st Case	1.5	34.0	48, 2	16.3	12	94	170	31°	7.9

Of the alternatives, conventional rail was eliminated because of the grade. The LHDs and FWD shuttle cars available, while able to operate at the tunnel grade, were too wide to permit safe passage in the normal drift diameter. A simulation by others showed that multiple vehicles and turnouts would be necessary to keep up with the expected TBM advance while downtime for cutter changes would leave a large equipment inventory idle.

References used in a belt conveyor study were the 1966 CEMA publication, "Belt Conveyors for Bulk Materials," (Reference 2), and "Catalog No. 66," Stephens-Adamson Mfg. Co. (Reference 3).

The first muck characteristic considered was the maximum block size. While the 12-inch maximum dimension would imply a belt width of 48 inches based on chute design, the small percentage of plus 3-inch material indicated that this would be relaxed to 42 inches or 36 inches. Using a surcharge angle of 15 degrees (16 degrees less than the "worst case" angle of repose), and considering a "lump" as plus 3 inches in size, the 36-inch choice is confirmed by Table 1-1, Reference 3, subject to capacity calculations.

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Choice of a general arrangement considered the TBM design and the supply transport system as well as the muck characteristics. The discharge from the TBM conveyor would be at 5 feet 3 inches below the tunnel crown over a head pully assembly 1-foot 9-inches deep. A 425-foot feeder conveyor hung from a monorail and a trolley is designed to travel with the TBM. Support for this assembly will be provided by roof channels rock bolted to the back; clearance to the invert will be 9 feet. About 4 feet of fill above the invert would be required to provide a flat surface wide enough for supply vehicles and a conventional conveyor. The fill would leave only 5 feet of clearance to the bottom of the feeder belt, and would have to be removed on completion to maintain the ventilation area for which the tunnel was designed. For these reasons, a rope belt, supported from the roof channels, was selected. To maintain adequate clearance from the floor, a 20-degree end roll angle is indicated by the geometry.

Belt speed is a function of cross section capacity, muck characteristics, and production rate. Anticipated production is $6 \times 257 = 1,542$ cubic feet per hour, or 262,140 pounds, which is equal to 4,369 pounds per minute. The cross section area of the belt is 0.684 square feet and is corrected for inclination. The dry, loose unit weight of the load is 94 pounds per cubic foot, or 63.4 pounds per linear foot of belt. Because the belt will be suspended over personnel and supply traffic, the edge distance is increased to 0.20 b by applying a factor of 0.45, extrapolated from Table 3-9, Reference 2. This results in a load per linear foot of 63.4 x 0.45 = 28.53 pounds, and an indicated belt speed of 4,369/28.53 = 153 feet per minute.

Troughing idler spacing was selected at 5.0 feet from Table 4-1, Reference 2, with a return idler spacing of 10 feet. Service factors, A = 15 and B = 56, result in application factors of III for troughing and return idlers requiring 5-inch diameter rolls. Because of the high

percentage of fines, self-cleaning return idlers are indicated. Anticipating heavier service in another application, a 6-inch diameter roll is selected.

The length of a flight is a function of the length of the feeder conveyor and the tunnel length; 1,200 feet is selected as compatible with both. Calculation of required power in the case of a declined belt does not include a friction allowance for grease and seal friction because these may approach zero under some conditions, and cannot be depended upon to retard the belt.

Reduced friction belt tension (T_e) becomes a function of the length (L), a temperature factor (K_t), the revolving idler resistance (K_x), the belt width (W_b), the moving resistance of the loaded belt (K_y), the weight of the belt load (W_m), the elevation change (H), a reduced friction factor (C_1), and the resistance of the nondriving pulleys and skirt boards. Substitution in the formula (Reference 2) gives a tension of minus 5,632 pounds. Use of this value and the velocity (V) with the power formula (Reference 2) results in a belt horsepower of minus 26.1.

Adding 6 percent for speed reduction losses, the motor shaft horsepower becomes 24.5. This is the power required to retard the conveyor velocity in normal operation, and is subject to review under empty and partial loading conditions. A brake would be necessary to decelerate and hold the belt under conditions of power failure and must be designed not to overstress the belt. Since the flights will operate as parts of a system, sequence starting and stopping will be necessary to prevent pile ups at transfer points. Belt cleaners and possibly water sprays would be required because of the fines. Choice of a belt will depend not only on tension and service factors, but also on fire retardant characteristics. Detailed definitions of these system components is beyond the scope of this program, but the foregoing discussion and the detailed calculations shown in Appendix B serve to demonstrate the use of MDN data and a manual method of determining equipment requirements.

3.7.6 Example 4: Conventional Rail Systems

The major application of MDN data to selection of a rail haulage system is in the elimination of other subsystems from consideration. Rail haulage is adaptable to any MDN, and final design usually is dictated by space, production, and safety considerations. Other MDN applications possible are the use of shape, size, and consistency data in the designs of cars, car dumps, and storage facilities. As examples, a rotary car

dump used with MDN 7 muck characterized by a high fines content operated well with two men while a MDN 2 muck, with a relatively low percentage of fines from a similar formation, required three men to unload and clean side dump cars in about twice the time. Either dumping method could have been improved by rubber half-liners. Similarly, two rather elaborate bin and chute installations could have been predicted to rathole as they did with platy MDN 3, 4, and 5 muck, while alternate bin designs might have eliminated through dumping and extra manpower. In still another case, anticipation of the large slab size and the characteristics of material with high liquid and plastic limits could have resulted in a car-dump, pug-mill conveyor design which worked well in place of one which was able to handle only about ten percent of the muck from a 5-mile, soft ground tunnel, and was replaced by an expensive and relatively inefficient alternate.

3.7.7 Equipment Selection Methods

The manual procedures illustrated for belt and hydraulic conveyor subsystems are obviously time-consuming and subject to a high degree of human error. Requiring many manipulations of the same or variations of the same data, they are often bypassed by the expedient of specifying performance and accepting vendors' recommendations with only a cursory intuitive verification by the contractor.

As tedious, repetitive mathematical operations, both procedures are excellent subjects for computer programmed solutions. With the increasing familiarity of construction organizations with computer techniques, there is no question that proven computer programs would be valuable tools for job planning, and could prevent costly errors in equipment application. Considerable effort has been expended in resolving apparent conflicts in design philosophy. Areas which appear to require further study are described in the section of this report which deals with implications for further research.

The parametric mathematical models described in HN-8080, "Materials Handling for Tunnels," referenced in Appendix E, were reviewed for application in this study. It is apparent that muck size and size distribution, on which MDN are based, as well as other physical property characteristics determined in the program, can be used as input for the design formulas and the models. However, modification and refinement of the models, originally developed for the high advance rates of the future, will be necessary for direct application to current operations. Other computer programs investigated were held to be proprietary. Time and funding of this program

are insufficient for further investigation, or for the development of in-house programs.

Differences of opinion exist concerning the adequacy of the conventional methods of muck transportation for tunnel advance rates which are not far in the future. These unresolved differences illustrate the fact that no rapid, economical method of evaluating system capability has been developed for tunnel operations. Our experience in computer simulation indicates that this technique could produce excellent results. A successful demonstration, however, would require factual information on operational times, and delay frequency and severity, in order to model real life performance. A demonstration should also include a lay term explanation of the technique, since any successful method of selecting the best methods and equipment for tunneling must compare possible alternates in a way which can be understood and accepted by the user.

4. DoD IMPLICATIONS

The advantages of siting many DoD installations underground and the virtual necessity of such sites for some installations have been discussed by many authors in such diverse publications as science fiction and U. S. Government reports and will not be repeated here. The potential value of underground sites for joint use has received somewhat less publicity, but is illustrated well by concepts such as the Manhattan Island Parking Garage and Blast Shelter, an evaluation of which was prepared by Holmes & Narver, Inc., for the Oak Ridge National Laboratory in 1967 (ORNL TM 1381). The study defined cross-town vehicular tunnels connecting the Lincoln and Queens-Midtown, and an underground complex which would provide subsurface parking for 30,000 cars, as well as emergency housing for nearly two million people. The impact of one or many such facilities on national defense capability could be enlarged upon at length. With current population and mobility growth rates, increased use of underground siting for many purposes is a certainty. The importance of tunneling to weapons test programs requires no evidence in a report to the DoD. Any action which will increase the speed and productivity of any part of the tunneling system will decrease the cost of an operation on which a significant part of the DoD and the national budgets will be expended in the future.

It is apparent that muck handling is a significant part of the cost of any tunnel operation. Current selection of tunnel transportation systems often is based on availability, intuition, and contractor familiarity with the equipment used at other sites. In some cases, the choice has been completely unsuitable for the muck produced. This has resulted in delays and additional expense which may be avoided by use of the information collected by the MDN study.

Other investigations have implied that major modifications of conventional equipment or design of completely new systems will be necessary to dispose of the muck from the high speed excavation systems predicted for the future. Muck characteristic data is a requisite as a basis for the engineering design of such system improvements or of innovative systems.

As an alternate to the design of a haulage system suitable for handling a particular muck, it may be practical to change muck characteristics at the face to provide a suitable feed for a handling system particularly well adapted to the tunnel site. MDN data will be invaluable to the selection of the necessary processing equipment.

Another alternate is to provide a continuous transport system such as hydraulic or pneumatic for the major volume of the muck, and temporary storage, as in a trailer or muck car, for a minor quantity of oversize which would be handled separately. Again, muck characteristic data is a necessity to design the separation equipment and the secondary system.

The data accumulated under the program are nonexistent in usable form elsewhere. While some TBM manufacturers and operators use muck size as an indicator of cutter efficiency, changes are noted during informal inspections at the machine and are seldom recorded except to show a need for cutter replacement. A few screen analyses have been run, but results normally are not made available outside of a manufacturer's or contractor's organization.

In use of MDN data, it is probable that potential improvements in transportation systems will appear. Where such improvements require the application of techniques which are technically sound but not developed to a point of practical application, they should be identified as attractive areas for research.

In summary, the MDN program has provided a part of the basic data required for a rational, engineering approach to problem solutions in a most important subsystem of the rapid excavation process. It illustrates application of data, identifies areas in which improvements are possible, and should be used to identify other areas in which research and development of modifications or new methods would be most productive.

5. IMPLICATIONS FOR FURTHER RESEARCH

5.1 SAMPLE AND DATA COLLECTION

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The following samples have been collected, including 18 in 1972 and one collected but not tested in the 1971 program.

	Rock Strength					
Excavation Method	Very High	High	Medium	Low	Very Low	Total
Conventional	3	9	5	1	1	19
Shield	0	0	0	0	2	2
Machine Drag Cutters Disc Cutters Roller Cutters Combination Cutters	0 2 0	1 7 3	1 5 1	2 1 0	1 0 0	5 15 4 7

The program has produced samples from 11 operations and/or formations which were not sampled previously. To conform to good sampling and testing practice, the reliability of the data should be confirmed by repetition, preferably of all single tests.

While the major interest of the program is in strong rocks, variations in muck characteristics with strength can only be demonstrated by sampling the full range of rock strengths excavated by any one method. As they are available, additional sites should be sampled in formations of varied strength, including the fine-grained igneous and volcanic rocks, of which no examples have been available.

Statistically, the number of samples used in developing a predictor equation should be much greater than the number of the variables used in the analysis. Because the reliability of prediction is of major importance, samples should be obtained from the following operations.

1. Drag Cutter Machine excavation in High, Medium, and Low Strength rocks. These samples would provide a

confirming data set in each strength category, and a total number of samples larger than the number of variables.

- 2. Roller Cutter Machine tunneling to provide confirming data on this method.
- 3. Combination Cutter Machine excavation in Low Strength rock to confirm data from a single sample collected previously.
- 4. Conventional tunneling in Low and Very Low Strength rocks to confirm data from single samples collected previously.
- 5. Disc Cutter Machine tunneling in Low Strength formations to improve the spread of the data on this method.
- 6. Disc Cutter Machine tunneling with tungsten carbide button insert cutters as a promising development in machine excavation of strong rocks.

Samples and data should be collected from tests of the unusual rock breaking techniques under development, including the electron beam, the water cannon, the conical borer, and continuous application of explosives. Muck data will be necessary to define applicable transport systems, which must be considered in evaluation of any excavation method.

No appropriate operating parameters for Atlas-Copco and Alpine TBMs could be developed under the current program. Some progress was made in determining effective torque for TBMs, but to do so involved getting manufacturers' data on motors, gear reducers, and/or hydraulic pumps, and motors as well as ampere draw data under operating conditions. The time and cost of collecting these data were beyond the scope of the program, but should be budgeted in any future work.

5.2 PHYSICAL TESTING

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Physical property testing should continue as in the past, since all commercial test data appears important to one of the predictor equations, and the PMSRC data remains to be evaluated.

Abrasiveness testing should be initiated as soon as possible and continued to provide data for the design and cost analysis phase of equipment selection.

The modified Protodyakonov test for resistance to fragmentation should be investigated for effectiveness and cost to evaluate development of data on this rock property for use in regression analysis and prediction of MDN.

5.3 DATA ANALYSIS

Although many iterations of the regression analysis were performed, many other combinations of variables are possible. Construction has been suggested of a dummy variable for rock classification which would indicate class membership instead of the progression used. A trial also should be made of a correlation using a combination of RQD with hardness and modulus of elasticity alone, but time and funding did not permit analysis using all of the variations which might have improved prediction accuracy. Similarly, since dry unit weight was an important variable in all regressions, it appeared reasonable to substitute specific gravity for values of DUW to evaluate the significance of the same property without the effect of porosity. No analysis of data provided by FMSRC testing was made, because commercial data appeared to be more significant in preliminary analysis, and later addition of variables was impractical. Correlation using all of the variables finally available should be tried as well as other combinations which may appear advisable. Generally, development of regression coefficients which result in large residuals for some observations, indicates that the input data should be reviewed in search of valid reasons for modification. This was done following the preliminary analysis, but not following the final, and should be included in any future work.

5.4 METHODS DEVELOPMENT

The original proposal included time and funds for a thorough review of transportation subsystem design procedures, and for the development of improved methods where possible. When a scope reduction to the fund level of the current contract became necessary, it was agreed that this activity would be confined to an example of MDN application to each of the subsystems in common use. The examples are provided in Section 3, and detailed supporting calculations are shown in Appendix E. They show clearly the time-consuming nature of manual calculations for even a preliminary study of belt and hydrausic conveying feasibility, and indicate the additional calculations necessary for final design.

Mathematical procedures which are tedious, repetitive, and subject to gross error when performed manually are excellent prospects for computer applications. Under these criteria, design practices for both types of conveyors qualify eminently. Some areas in which clarification appears necessary include a formula for clear water head loss which produces results varying by more than 60 percent from those tabulated in standard reference works, and published data correlating belt width and lump size which show data points so far separated that the validity of interpolation is cuestionable. Undoubtedly, these and other problem areas could be rationalized by further study. Proven proprietary subroutines are reported in use by specialists in both fields. The mathematical subsystem models referenced in Section 3, although requiring modification for application to current operations, indicate that computer programs can be developed which would produce hardware selections from a minimum of input rapidly and at a reasonable cost.

As discussed in Sections 1 and 3, existence of computer design programs in the public domain could reduce contractor dependence on specialists, and provide useful tools for selection of transport system components which meet the requirements of total systems. These tools should be developed by further research. Another such tool which should be developed is system simulation, which could provide a rapid and economical means of comparing the performance of available subsystems, or of variations within a single transport system.

Two factors combine to limit acceptance of computer simulation by industry. One is lack of confidence in an unfamiliar technique which normally is described in an equally unfamiliar language. The second is a lack of the performance, delay, and cost data required for reasonable correlation between model and real-life performance. Development of a data bank would solve the second problem. Description in lay terms of the technique as the simple system which it is, and demonstration of its effectiveness could go far towards solution of the first problem. Both are recommended as subjects for future investigations.

5.5 CONCEPT VALIDATION

The validity of the MDN concept could be demonstrated best by using the predictor equation to calculate MDN for proposed tunnels in advance of construction, using the data to select transportation subsystems and components, and comparing the predicted muck characteristics and the selected transport systems with the muck produced and the subsystems actually used. This approach is recommended.

6. SPECIAL COMMENTS

A Schmidt rebound hardness tester and two MSA self-rescuers were purchased for use in the current program. No invention has been made in the course of the work performed under this contract.

GLOSSARY

ASTM	American Society for Testing and	PF PMSRC	Powder Factor Pittsburgh Mining
D14	Materials		and Safety
BM	Beam	700 m	Research Center
CFM	Cubic feet per minute	POT.	Potential
CNTR	Center	PSF	Pounds per square foot
COMPR.	Compressed	PSI	Pounds per
CONTIN.	Continuous		square inch
CONV	Conveyor	Rect.	Rectangular
CY	Cubic Yard	REG.	Regular
DEG.	Degrees	RBM	Raise Boring Machine
DIA.	Diameter	RPM	Revolutions per Minute
DUW	Dry Unit Weight	RQD	Rock Quality
Est, (E)	Estimated		Designation
FWD	Four Wheel Drive	SF	Square Foot
GPM	Gallons per Minute	ST	Scoop Tram
HP	Horse Power	SPECIF'.	Specific
HRS.	Hours	STRNTH.	Strength
IN.	Inch	TBM	Tunnel Boring
INTEG	Integral		Machine
Inter.	Internal	TC	Tungsten Carbide
K	Thousand	TCB	Tungsten Carbide
LBS, #	Pounds		Button
LHD	Load Haul Dump	T	Tentative
LT	Long Ton	T.	Ton
MDN	Muck Designation	V	Volt
	Number	VOL	Volume
MAX	Maximum	w/	With
Moist.	Moisture	wr.	Weight
MM	Millimeter	1	Foot
NA.	Not Available	11	Inch
NO.	Number	#	Number
PCF	Pounds per	%	Percent
	Cubic Foot	(+)	Plus
PCT	Percent	(-)	Minus

APPENDIX A

TUNNEL PROJECTS AND CONVENTIONAL DEEP MINE SITES

TUNNEL PROJECTS

A list of operating and scheduled tunnels, prepared originally to assure that program objectives could be met, was revised periodically; but has not been brought up to date because of the termination of the program. Excerpts from the last revision are reproduced below to illustrate the form and content.

OPERATING AND SCHEDULED TUNNELS

Compiled by Holmes & Narver, Inc., Anaheim, California, under U. S. Bureau of Mines Contract H0220023. Revised September 1, 1972

NORTH AMERICAN CONTINENT

Project and Location	Owner or Agency	Size	Length	Contractor
San Manuel Mine San Manuel, Arizona	Magma Copper Company	12'x12'	Various	Own Force

Main level drifting on two levels in quartz monzonite and monzonite porphyry, concurrent with shaft sinking to 3,700-foot depth. A 9,000-foot drift is planned to explore a new ore body from the bottom level of the new shaft.

Tonner	The Metropolitan	11'6"	#1 - 4,589'	Shea
#1 and #2	Water District of &	Diameter	#2 - 19,360'	Construction
Brea, Calif.	Southern Calif.			Company

A Calweld machine is being assembled at the site to bore low strength sandstone and siltstone. Geologic data and cores are available from the owner agency.

Nast Tunnel	U. S. Bureau of	10'	3 Miles	Peter Kiewit
Fryingpan	Reclamation	Diameter		Sons
Project	Denver,			Company
Merideth,	Colorado			
Colorado				

A Wirth boring machine has been replaced by conventional drifting in fault zones, and is scheduled to resume work in more competent rock in November, 1972. Formations are predominantly granite, granite gneiss, granite porphyry, and granodiorite with compressive strengths from 18 K to 24 K psi. Rock is highly sheared in zones from a few feet to 400 feet thick.

DEEP MINE SITES

In response to an expression of interest by an ARPA representative, the Project Officer requested the inclusion of deep mine sites with the conventional operations sampled in the second year of the program. It was agreed that additional data on operating practices peculiar to such sites would be collected. Six samples for the basic program were collected from five sites at depths of more than 3,400 feet below the surface. Data normally collected is presented in Appendices B and C. Other information, beyond the scope of the data formats, is provided in this appendix.

Magma Mine, Superior, Arizona

Rock and muck samples taken from the 3,400-foot level of this mine at a depth of 3,960 feet below the surface are identified as MSU-1 and MSU-2. Discovery of an ore body at this location in 1875 is reported in "Rock to Riches," Dunning and Peplow, 1966, which describes intermittent development until 1910 when the Magma Copper Company was organized. For the next 20 years, mining and development, including additional shafts, continued steadily in ore bodies which increased in size and value at greater depth. High rock temperatures were also encountered, and a cooling and ventilating system was installed in 1931. By 1957, the mine had reached 4,800 feet in depth, but operations at this level were suspended reportedly because of low productivity resulting from high rock temperatures. Development on higher levels continued principally to the east of the older workings. Although an unusually high grade of ore continued to be developed, increasing distance added to the cost of hoisting, haulage, supplies, and ventilation as well as personnel travel time.

Since 1969, a new 22-foot diameter, concrete-lined shaft and a surface plant have been under construction from a location about a mile east of the current major workings. The new shaft will provide access to lower levels down to the 4,200-foot level, which is over 500 feet below sea level, at a depth of nearly 4,300 feet below the shaft collar. Personnel and supplies, which formerly reached these

levels by way of an adit, a shaft from the 500-foot level to the 2,500-foot level, a mile of horizontal rail travel, and a second shaft, will reach the working levels directly from the new shaft. Ore will be hoisted to the 500-foot level in the new shaft and hauled to the mill through a 12.5-foot diameter tunnel which was driven by a TBM in 1969 and 1970.

Two Marley cooling towers have been installed with the surface equipment. One 7,100 gpm tower is used to cool compressors and AC units. A 5,000 gpm tower is used with one 700-ton and three 770-ton mechanical units to provide a 6,500-ton capacity system for underground cooling where rock temperatures of 115° to 138° are encountered in current operations and 150° is expected at greater depth. Chilled water at 55° to 60° is fed to 16-inch shell and 5/8-inch tube heat exchangers located in a 280-foot x 16-foot x 13-foot high alcove on the 3,000-foot level by a 16-inch insulated shaft pipeline. Return water at 85° is pumped to the surface through a second 16-inch line. From the exchangers, five 600-gpm, 500-psi circuits feed chilled water through 4-inch lines to working place spot coolers which are portable units with 40-hp compressors and 20-hp fans. Booster fans totalling 25 to 250 hp are installed in ventilation lines.

Ground support is not a major problem in development. Rock-bolted development drifts normally parallel the ore bodies in a medium to high strength conglomerate. The powder factor is above average; the percentage of minus 3-inch material is average or below. The 18-inch gage, light rail system in use throughout the mine for many years is being replaced by a 36-inch gage system on the 3,500-foot level and below. Eimco 21 loaders are used with 35- to 50-cubic foot cars in upper level development. With the wider gage on the 3,500-foot level, an Eimco 22 loader is used with two self-unloading, 15-cubic yard Hagglund shuttle cars. In combination with a company designed hydraulic dump, swing, and slide drill jumbo, the 3,500-foot level equipment is reported to produce about 38 percent higher footage per man-shift than the smaller equipment used on other levels.

Bunker Hill Company, Crescent Mine, Osburn, Idaho, and Hecla Mining Co., Star Mine, Burke, Idaho

Rock and muck samples from these mines are identified as CR-1 and ST-1. Both are in the Coeur D'Alene mining district which is an area of strong relief where surface elevations may vary by 600 feet in a quarter mile. Mining of zinc, lead, and silver ores in the area started in the 1880's and has continued to depths of 6,000 feet to 7,000 feet below the surface in veins which cut the quartzite and the

argillite country rock. Formations have been folded and faulted extensively, and the bedding normally dips at a steep angle.

Rock bursts, common throughout the district, are described in a 1970 technical paper by G. G. Waddell, Mining Engineer, U. S. Bureau of Mines, as "the sudden, violent release of stored strain energy in rock by some mechanism of rock failure, usually accompanied by expulsion of rock with considerable damage to the mine." Research into cause, occurrence, and control of bursts has been conducted by the mining companies and the Bureau of Mines over a considerable period. Prime locations for bursts in mine development work have been identified as areas in which a competent rock is in contact with a less competent one; areas in which the strike of the bedding is an an acute angle with the axis of the opening; and dead end openings with either or both of the contact/orientation factors present. An effective control measure in force is an interval of one or two hours between production shifts in which period most rock bursts occur. However, one district mine operator is reported by Waddell to estimate that the rock burst problem adds at least \$1 per ion to the cost of ore production.

The CR-1 sample was taken from a development heading on the 4, 100-foot level of the Crescent Mine at an elevation about 1, 400 feet below sea level, or 6,100 feet below the surface. The face was about 600 feet south of the shaft through which muck, men, and supplies were hoisted to and from the portal adit on the 3, 100-foot level. formation is a medium strength quartzite with minor-filled veinlets dipping at 75° to 90° . Fractures in the face dip at 45° and 10° . The rock requires more drilling time than had been expected, and only one heading of the two available is being driven. The rock temperature is 97° to 100°. Cooling is provided by a 120-ton Carrier AC unit located on the 3, 100-foot level about 1,000 feet above the 4, 100-foot level to maintain a wet bulb/dry bulb temperature of 850 at the face. Chilled water is fed to the AC compressor through a 4-inch insulated line, and is not recirculated. Two 40-hp fans draw air through the heat exchanger coils of the AC unit to pressurize 24-inch fiberglass ventilation lines through the shaft and the drift. The bolt pattern in the top is not unusual; plates and rock bolts are installed on the ribs as a precaution against slabbing or bursts. The powder factor is comparatively high, but the percentage of minus 3-inch material is average. The LHD unit and the diesel-powered, rubber-tired jumbo are reportedly fully acceptable to the miners and mine management.

Sample ST-1 was taken from a development heading on the 7,500-foot level of the Star Mine at an elevation of 1,744 feet below sea level, or 7,094 feet below the surface. The face was about 600 feet (800 feet

via the drift) south of No. 4 shaft. The shaft is operated from the 2,000-foot level and reached through a long adit from the portal. The formation is high strength argillaceous quartzite, moderately folded and fractured, and the rock temperature is about 115°. Cooling had been provided by a 200-ton Carrier AC unit on the 7,300-foot level with ventilation through a 24-inch shaft pipeline. As observed, the system was not operating; the air temperature equalled the rock temperature, and production had stopped. The rock-bolt pattern was normal for the district. One minor rock burst was said to have occurred about 400 feet from the shaft. The powder factor is normal, but the percentage of minus 3-inch material is the second lowest observed. Equipment appears well matched and adequate for the operation.

Homestake Mine, Lead, South Dakota

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Described by Dunning and Sadler in "Gold," 1970, as "the longest lived and greatest producer" of all gold mines, Homestake is also one of the deepest in the United States, with level development at 150-foot intervals to 7,100 feet below the surface, and a shaft under construction to lower levels. First operated as an open pit in the late 1870's, ore is currently produced from steep dipping, nearly parallel veins. The development observed was reached via the Yates shaft to the 4,850-foot level, a rail transfer, and a subshaft which services levels down to the 6,800-foot level. Sample HS-1 was taken from a 6,200-foot level heading in phyllite, a high strength, highly metamorphosed sediment with quartz and chlorite stringers.

Normal drift size has been 7-1/2 feet x 7-1/2 feet; the size is being enlarged to provide less resistance to air flow. Primary ventilation is provided by three exhaust fans rated at 1,300 KCFM. Fan power is being increased by over 60 percent to provide more air. Place temperatures up to 121° are reduced to a 74° to 85° range by 30- and 60-ton mechanical cooling units. Development ventilation lines are 16 inches in diameter. Ground support in development is minimal; rock bolts are installed only "as required." The depth of drill rounds (10 feet) is unusual for headings this size and the equipment used. The powder factor is relatively high, and the area per hole is the smallest observed; the percent of minus 3-inch muck is average. Production sustains good contract rates and appears to be satisfactory to management.

Mather "B" Mine, Cleveland Cliffs Iron Co., Negaunee, Michigan

This mine, first developed in the early 1940's, is located in a very old iron mining district known as the Marquette Range in the northern peninsula of Michigan. The iron-ore bodies are extensive, and are developed for block caving by drifts in waste and cross cuts in waste and ore. Sample MB-3 was taken from the twelfth level, west drift extension in a high strength graywacke (known locally as dirty quartzite) at an elevation of 2,030 feet below sea level, or 3,480 feet below the surface. Formations have been highly folded and fractured; normal bedding dip is 30° to 45°.

Development drifts near the ore bodies are normally supported in anticipation of increased pressure as mining approaches the level. The drift observed will connect with workings of an adjacent mine, the Mather "A," and was being driven without support. All haulage is rail, preferred over extensive belt conveyor installations previously used because of greater reliability. Relatively low rock and surface air temperatures result in no major cooling problems; heat is provided for winter operation of downcast shafts in some locations. The powder factor, the area per hole, and the percentage of minus 3-inch muck are above average. Rail, locomotives, cars, drill jumbos, and muckers are large and well matched as a result of extensive tests of many kinds of equipment.

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APPENDIX B
RAW DATA SHEETS

Identification	Page	Identification	Page
NAST-1	B-1-B-2	5-1	B-53-B-54
NAST-2	B-3-B-4	7-2	B-55-B-56
NAST-3	B-5-B-6	11-3	B-57-B-58
NAST-4	B-7-B-8	11-4	B-59-B-60
GA-l	B-9-B-10	72-1	B-61-B-62
H-1	B-11-B-12	MSU-1	B-63-B-64
H-2	B-13-B-14	MSU-2	B-65-B-66
H-3	B-15-B-16	LAW-2	B-67-B-68
LK-l	B-17-B-18	LAW-3	B-69-B-70
LK-2	B-19-B-20	LAW-4	B-71-B-72
LK-5	B-21-B-22	MIL-1	B-73-B-74
LK-6	B-23-B-24	M2	B-75-B-76
LK-7	B-25-B-26	MIL-3	B-77-B-78
SM-l	B-27-B-28	EVG-1	B-79-B-80
CL-1	B-29-B-30	EVG-2	B-81-B-82
LK-3	B-31-B-32	LAY-1	B-83-B-84
LK-4	B-33-B-34	LAY-2	B-85-B-86
MB-1	B-35-B-36	CNT-1	B-87-B-88
MB-3	B-37-B-38	NA V - 1	B-89-B-90
ST-1	B-39-B-40	NAV-2	B-91-B-92
CR-1	B-41-B-42	RO -1	B-93-B-94
HS-l	B-43-B-44	WNG-1	B-95-B-96
NY-1	B-45-B-46	WNG-2	B-97-B-98
NY-2	B-47-B-48	SF-1	B-99-B-100
QL-1	B-49-B-50	SF-2	B-101-B-102
MB-2	B-51-B-52	KM-1	B-103-B-104

NAST-1 CURRENT: 04/01/73

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PCT (-) N0200	S. 65	PESPHERO10				185 1N. ITER AT HOIST	
**************************************		A=ANGULAR SESUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMERGID		TOUGHNESS TOUGHNESS	0.10	SIZE(-)0.185 ANGLE INTER FRICTION DEGREES AT 8.5 PCT HOIS	24
21N. 11N. 1/21N. NO. NOB NOIG NOSO NOSO NOIG	6 11.8	1=IRREGULAR	s Is	I NOEX	3.0	BULK DENSITY PCF AT 0.0 PCT MOIST	85.16
0.00N	12.3 8.6	TY C=CUBIC	S S		m	HOIST	
EN SCREENS 18 NOIG	12.4	INDED P=PLA	¥.	PLASTICITY PLASTICITY INDEX PCT	0.50	POP PSF	X
IGHT BETWE NO4 NO	14.9 12.5	SULAR R*ROC	AI AI	175••S12E (*		(-) 0.50 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 9.0 PCT MOIST	
CENT BY WE	2.5	AR SESUBAN	i	ERBERG LIM SMRINK LIMIÑ PCT	13,50	SIZE(~) 0.50 ANGLE/SLIDE STEEL PLATE DEGREES AT 9.0 PCT NOI:	7
JIN. ZIN. IIN	0.0 0.0			PLASTIC SHRINKAGE PLASTICITY INDEX INDEX PCT	14.00	ANGLE/REPOSE 10 IN DROP DEGREES AT 9.0 PCT MOIST	36
6 *	0.0	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES		LIGUID LIMI1S PCT	14.50	• •	
JRE PCT(+)6 IN-SIZE	0 • 0	TIONS BETW		512£		ANGLE/RE 1 IN DRO DEGREES 9.0 PCT	37
IIT MOISTURE	4.0	PE OF FRAC		POT VOL CHANGE (~) 0.065 IN.SIZE		(+) 0.501N.S.ZE SPECIF GRAVITY	5,69
MUCK DATA DRY UNIT WT PCF	83	AHS.			c	(*) 398 898	Ň

POISSON RATIO

YOUNGS MOD. PSIX10E6

SHORE SCHMIDT

ROD PCT EST

COMP SIRNTH KPSI

ORY WI PCF

ROCK PROPERTIES
1GNEOUS: GRANITE, GRAY, MEDIUM
TO FINE GRAINED, MODERATELY TO
SLIGHTLY FRACTURED AND JOINTED
10 TO 20 PCT QUARTZ, SO TO 60
PCT FELDSPAR, BALANCE DARK
MINEKALS,

IDENTIFICATION NAST

SAMPLE NO

167

0.30 NOTE

8.50 NOTE

S1 NOTE

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NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZIO043-72.

B-1

	DATA
KEY	1A TUNNEL

TUNNEL			VENT	VENTILATION				WATER INFLOW	UTILITY LINES	POWER SYSTEM	STEM
S12E 9FT 9IN	SHAPE	GRADE C	CFR 104	PRESS	EXHST X	S12E 221N	£	БР М 5-20	AIR WATER PUMP 6IN 2IN 6IN	PRIMARY 4150V	PRIMARY SECONDARY 4160V 480V
HAULAGE SYSTEM	SYSTEM					SUPPORT	SUPPORT SYSTEM				
MUCK RAIL. 36IN GAGE. 70LB PAIL. 16 CY CARS	SIN SIN S CY	PERSONNEL Rail		SUPPLY		801 1, 1Y 4-1 1N X 620UTED	BOLT, TYPE SIZE 4-1 IN X 7FT GAOUTED	ROOF PLATE 131N X 10FT 16 GAGE	SET.SIZE.SHAPE 4IN RING AND HALF SETS 4FT. 3FT. AND 2FT IN BAD GROUND	SHOTCRETE	

MACHINE EXCAVATION

MACHINE			CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	E.DIAM.CUTTING	s EDGES	A G	TORQUE, MAX/OPERATE	/OPERATE	THRUST . MAX/OPERATE
MAKE MOO WIRTH HAR	MODEL HARDROCK	#1 67 10\S	CENTER 2 HUGHES/WIRTH TCB 11.51N POLLER 2-TCB 11.51N TCB CONE	INTERIOR 15 HUGHES/WIRTH 6 108 11.51N I	GAGE RTH 6 HUGHES/WIRTH ICR 11.51K TCB ROLLER	HEAD.CENTER	TER HEAD EG KFTLR 150 KFTLB 110	CENTER KFTL8 KFTL8	KLB 290 KLB
ANCHOR PRESS KLB	SS MUCK SYSTEM BUCKET FROM FACE, 22IN CONVEYOR TO	SYSTEN I FROM 221N FOR TO	POWER SYSTEM HYDRAULIC+ POWERED BY 3-200MP MOTORS		GUIDANCE THRUST/SQ FT KERF SPACING ADVANTE PER LASER KLB 3.89 0.09 2.6	SPACING ADV	VANCE PER Hour.ft. 2.6		

CONVENTIONAL EXCAVATION

ROUND.	NO. HOLES POWDER FACTOR	₩1430		.	CONTROL -
MACHINE	JUMBO	MACHINES		FEED LENGTH	

GUIDANCE

MUCK ING

BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES YES BELT CONV. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES** *POSSIBLE,TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.

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			PCT (-) NO200	6	PHE RO 10				* * *	
POISSON RATIO	0.30 NOTE		NOZON NO	7	R=ROUNDED P=PLATY C*CUBIC I*IRREGULAR E*ELONGATED SP=SPHFROID		• • • • • • •		SIZE(=)1.0 II ANGLE INTEP FRICTION DEGREES AT 8.5 PCT MOIST	31
YOUNGS MOD. PSIX10E6	8.50 NOTE		NOTICO	it.	AR E=ELO	-	TOUGHNESS	0.28		
:5	S1 4		NO50	7.7	I=IRREGUL	v	. X		BULK BULK DENSITY PCF AT 0.0 PCT HOIST	84.53
SHORE SCHMI	₹	SPECIMEN. .40210043-72.	N030	9•9	C*CUBIC	15	FLOW	4.6	•	
ROD PCT SI	06	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.HO210043-72	SCREENS	11.5 10.3	P=PLATY	A1 SE	056IN TICITY X		APPARENT COHESION PSF AT 8.5 PCT MOIST	0
COMP STRNTH KPSI	8	3. UNPOLISHED FROM CSM A.R.	BETWEEN S NOB	13.8 11	R#ROUNDED	ï d	IZE(~) 0.0 PLAST INDEX PCT	1.3	• • • •	
DRY PCF	167	546610-66. t VALUE. 6.	ZIN. 11N. 1/21N. NO4	25.0	A=ANGULAR S=SUBANGULAR I	I d	PLASTIC SHRINKAGE PLASTICITY STRUCT PLASTIC LIMIT INDEX PCT PCT	17.9	L.O.LDE C.E. PLATE REES AT PCT HOI	64
GRAY+ MEDIUM HODERATELY TO D AND JOINTED	40 60 ARK	M D.U.DEERE AD 646610-66. ASSIGNED MINIMUM VALUE.	PER CENI	0.8 8.0	=ANGULAR S=	Id	IC ATTERBER		S12(
ES ITE GRAY. ED MODERA TURED AND	BAL BAL	0 FR0 5.	•	0.0			PLAST	18.2	ANGLE/RE 10 IN DK DEGREES 8.7 PCT	38
ROCK PROPERTIES IGNEOUS: GRANITE. TO FINE GRAINED: H SLIGHTLY FRACTURED	10 TO 20 PCT (PCT FELDSPAR, MINERALS,	NOTES: 1. 80 PCT, OF FORMATION. 2. INFERED 1. INFERRED FROM TESTS/SIMILAR ROCK.	PCT(+)6 ***** IN.SI7E 6IN.		FRACTIONS BETWEEN SCREEN SIZES		LIGUID LIMITS PCT	19.5	**************************************	_
	~ C X	FORMATION.	STURE	10.8 0.0	FRACTIONS 8		HANGE IN.SIZE			38
IDENTIFICATION NAST SAMPLE NO	VAST-2	ES: 80 PCT. OF INFERRED FI	CATA UNIT PCF	76 10	SHAPE OF (POT VOL CHANGE (-10.056 IN.S	ဗ	(~) 0.501N.SIZE SPECIF GRAVITY	2,66
RE Z		NOTES:	M UNC			B-3				

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	DAT
KEY	2.A TUNNEL

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STEM	PRIMARY SECONDARY 4160V 480V		
POWER SYSTEM	PRIMARY 4160V		SHOTCRETE
UTILITY LINES	AIR WATER PUMP 6IN 2IN 6IN		SET.SIZE.SHAPE 4IN RING AND HALF SETS 4FT. 3FT. ANJ 2FT IN BAD GRÖUND APPROX. 650FT
MATER INFLOW	бри 5-20		ROOF PLATE 131N X 10FT 16 GAGE
VENTILATION	ORESS EXHST SIZE HP	SUPPORT SYSTEM	SUPPLY BOLT.TYPE SIZE ROOF PLATE RAIL 4-11N X 7FT 131N X 10FT GROUTED APPROX. 16 GAGE 1200FT
VEN	GRADE CFM +0.22PCT 10K		P.T. JUNEL RAIL
TUNNEL	SIZE SMAPE GFT ROUND 91N	HA LAGE SYSTEM	MUCK RAIL, 361N RAIL, 361N RAIL, 16 CY CASS MOTOR 12 TON

MACHINE EXCAVATION

THRUST . MAX/OPERATE	KL8 290	
	CENTER KFTL8 KFTL8	
TORGUE . MAX/OPERATE	HEAD KFTLB 150 KFTLB 110	3 4 PER
# da	HEAD.CENTER B.S INTEG	ING ADVANCE PER HOURSFT. 2.3
œ	GAGE 6 HUGHES/WIRTH B TCB 11.5IN TCB ROLLER	KERF SPAC 0.09
s EogEs	6.06E 8TH 6 HUGHI TCB 31. ROLLER	THRUST/SQ F1
.DIAM.CUTTING	INTERIOR IS HUGHES/WIRTH TCB 11.5IN ROLLER	GU I DANCE Laser
CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	CENTER 7 HUGHES/WIRTH TCB 11.5IN ROLLER, 2-TCR 11.5IN CONE	COWER SYSTEM HYDRAULIC+ POWERED BY 3-200HP MOTORS
	WT 67 10kS	MUCK SYSTEM BUCKETS FROM FACE, 221N CONVEYOR TO REAR
	MODEL Hardrock	ESS MUCK BUCKE FACE, CONVE
MACHINE	ERKELENZ HIR HIR HIR HIR HIR HIR HIR HIR HIR HIR	ANCHOR PRESS KLB

CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS,	INTERIOR CUT 1 IFFED
ROUND. NO. HOLES DEPTH DIAM.	•
MACHINE MACHINES	FEED LENGTH

GUIDANCE

MUCK ING

BLASTING

BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
IRANSPORT SYSTEM CAPABILITY:CONVENTIONAL PAIL YES SIDE RAIL YES.
FREE VEHICLES YE'S BELT CONV. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES.
*POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.

NAST-2 MDN 7

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legal repositions

TOUGHNESS INDEX	0.51	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 3.0 PCT MOIST	8
FLOW TOUGHNESS INDEX INDEX	4.10	BULK DENSITY PCF 11 0.0 PCT MOIST	91.2
E(+) 0.056IN PLASTICITY INDEX PCT	2.09	APPARENT COHESION PSF AT 3.0 PCT MOIST	08
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	17.13	ANGLE/REPOSE ANGLE/SLIDE 10 IN DROP STEEL PLATE DEGREES AT DEGREES AT 3.8 PCI MOIST 2.8 PC; MOIST	31
•	17.41	ANGLE/HEPOSE ANGLE/HEPOSE 10 IN DROP DEGREES AT 2.8 PCT HOIST	36
LIGUID LIMITS PCI	19.50	LEZREPOSE N. DROP REES AT PCT HOTST	34
POT VOL CHANGE	0	(-) 0.75IN.SIZE ************************************	5,65

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGULAR SESUBANGULAR REROUNDLO PEPLATY CECUBIC IMIRREGULAR EMELONGATED SPASPHEROID

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B - 5

PCT (+) NO230	3.8
* ZIN. 11N. 1/ZIN. NO4 NO8 NO16 NO30 NO50 NO100 NO200	1.5
NOSO NO	6.2 12.6 13.7 8.9 5.8 5.3 6.1 2.6 2.8
NO 30	.1 2.6
EN SCREENS 8 NO16	5,3 6
IGHT BETWEI NO4 NO.	5.8
CENT BY WE	3,7 8,9
ZIN. 1IN.	15.6 1
S S S S S S S S S S S S S S S S S S S	16.2 6.2
PCT(+)6 IN-SIZE	2.41
MOISTURE PCT	3.4
MUCK DATA DRY UNIT	g-m

NUTES:
1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEFRE AD 646610-66. 3. UNPOLISHED SPECIMEN.
4. INFERPEC FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

POISSON RATIO	0.35 Note 2
YOUNGS HOD.	8.32
SHORE SCHMIDT	52 NOTE
SHORE	6
8 P C T	60
COMP	28 28
DRY MT	16 4
ROCK PROPERTIES 16NEOUS: BIOTITIC GRANITE FINE GRAINED, MAJOR QUARTZ, MINOR	CONTENT.
KEY IDENTIFICATION 3 NAST	SAPPLE NO

the commercial or an array program on a

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NAST-3

SET.SIZE.SHAPE NA UTILITY LINES WATER A18 618 ROOF PLATE 131N X 10FT 16 GAGE WATER INFLOW GPM 5-10 BOLT.TYPE SIZE IIN X 7FT GROUTED SUPPORT SYSTEM 읖 S12E 221N PRESS EXHST SUPPLY RAIL VENTILATION 10K PERSONNEL Rail GRADE 0.0 RAIL 36IN GAGE. 70LB RAIL. 16 CY CARS MOTOR 12 TON SHAPE HAULAGE SYSTEM 3A TUNNEL DATA S12E S1 10FT X A1 16FF X8FT TOWNET X C C X KEY

MACHINE EXCAVATION

THRUST.MAX/OPERATE 7 7 8 5 8 6 CENTER TORQUE . MAX / OPERATE KFTLB KFTLB KF7LB KF7LB HEAD ADVANCE PER HOUR . FT. HEAD . CENTER KERF SPACING A DE FEET GUIDANCE THRUST/SQ FT GAGE CUTTERS, MAKE, TYPE, DIAM, CUTTING EDGES χľ INTERIOR FOWER SYSTEM CENTER ANCHOR PRESS MUCK SYSTEM 5 HODEL MACHINE 工业大学 B

CONVENTIONAL EXCAVATION

EXPLOSIVES,
POWDER FACTOR 6.3LB/CY
TOTAL LBS 300 GELEX 2, 60PCT
PRIMERS,
TRIM
INTERIOR
CUT DOUBLE V DIAM. 1-3/41N NO. HOLES 72 DEPTH 9F? SF/HOLE 2.2 ROUND. CUT. MACHINES JACK LES 2-553F F-ED LENITH 4FT MACHINE JUMBO

BLASTING EL FCTRICAL 0-7 REGULAR DELAYS

GUIDANCE MUCKING 1/2CY DIESEL FRONT END LOADER

RASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PHEUMATIC PIPELINE NO *POSSIBLE:TECHNOLOGY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH. WEAR. DAMAGE. (3) EXCESSIVE IIPE WEAR PROBABLE.

LIFTERS

SHOTCRETE

SECONDARY

PRIMARY NA

POWER SYSTEM

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			_		9					
			PCT (-) N020L	6.0	SP¤SPHERO I D				ž Ļ	
POISSON	0.33 NOTE		NO200		NGATED SP		• • • • • • • • • • • • • • • • • • •		SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 7.1 PCT MOIST	33
YOUNGS MOD. PSIX10E6	8.30 NOTE		N050 N0100	5.8	R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED		TOUGHNESS INDEX	90.0		•1
NESS SCHMIDT	\$2	•	NO50	4.4	1=IRREGU	∢	LOW NDEX	3.40	BULK BULK DENSITY PCF AT 0.0 PCT MOIST	-
SHORE SCHMIDT	4 7	SPECIMEN. H0210063-72,	NO30	14.5	C*CUBIC	•	i la. 1-4	e.		
800 PCT EST	0	HED SPEC	SCREENS	7 11.0	P=PLATY	1 V 1	PLASTICITY INDEX PCI		• 0	0
COMP STRNTH RPSI	5 8	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.HO210043-72	BETWEEN SC NOB	.6 12.7	ROUNDED		SIZE(+) 0.0' PLASI INDEX PCI	0.23	INAPPARENT COHESION PSF AT ST 7.1 PCT M	
				20.6 13.		I d	ITSSIZI AGE		SLIDE PLATE S AT MOIST	
DRY WT PCF	160	AD 645610-66. IMUM VALUE.	PER CENT RY W 11N. 1/21N.		S*SUBAN	I d	SHRINKA SHRINKA LIMIT PCT	17.50	SIZE(*)2.0 ANGLE/SLIDE STEEL PLATE DEGREES AT 6.9 PCT MOIS	04
GRAINED IAJOR AR		M D.U.DEERE AD 646610-60 ASSIGNED MINIMUM VALUE.	:	0.0	A#ANGULAR S#SUBANGULAR	•	PLASTIC SHINKAGE LIMITS. PLASTIC SHINKAGE LIMIT PCT			
FINE RED. H FELDSP		FROM D.U 5. ASSIG	.~	0.0			PLASTI LIMIT PCT	18.97	**************************************	34
ROCK PROPERTIES IGNEOUS, GRANITE, WODERATELY FRACTU CONTENT	•	Δ.	• • • • • • • • • • • • • • • • • • •	0 • 0	SCREEN S		•	•	•	
ROCK PRO IGNFOUS. NODERATE QUARTZ A		===	PCT(+)6 In.SI7E	0	OF FRACTIONS BETWEEN SCREEN SIZES		LIGUID LIHITS PCT	19,20	ANGLE/REPOSE 1 IN DROP DEGREES AT 6-9 PCT HOIST	o.
₹		" PEST OF FORMATION." A INFEREU FROM TESTS/S	MOISTURE PC	0.0	ACTIONS		NGF N.SIZE			G.
IDENTIFICATION NAST SANDLE NO		CI. OF F		17.2	E OF FR		POT VOL CHANGE (+)0.056 IN.SIZE		(+) O.751N.SIZE SPECIF GRAVITY	4
		1, 7, 5; 1, 80 PC	MUCK DATA DRY UNIT	83	3 d7HS		(-)	o	(*) 0.75 SPECIF GRAVITY	2.64
* * ** *					B	-7				

	DATA
KEY	TUNNEL

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POWER SYSTEM	SRIMARY SECONDARY 4160V 480V		
POWER	4 1 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		SHOTCRETE
UTILITY LINES	AIR MATER PUMP Sin 21% 61%		SET.SIZE.SMAPE 4IN RING AND HALF SETS. 4FT. 3FT. AND 2FT IN BAD GROUND APPROX. 650FT
WATER INFLOW	6PH 5-20		ROOF PLATE 131N X 10FT 16 GAGE
	ON 3218	SUPPORT SYSTEM	60LT.TYPE SIZE R 4-11N X 7FT I GROUTED I
VENTILATION	PRESS EXHST SIZE X 22IN		SUPPLY RAIL
VENT	GRADE CFM +0.22PCT 10K		PERSONNFL RAIL
TUNNEL	SIZE SHAPE 9FT ROUND 10IN	HAULAGE CYSTEM	MUCK RAIL+ 36IN GASE+ 70LB RAIL+ 16 CY CAMS MOTOR 12 TONS

MACHINE FXCAVATION

MACHINE		CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	DIAM.CUTTIN	G EDGES	Z Q	TORQUE . MAX/OPERATE	OPERATE	THRUST.MAX/OPERATE
HAKE HOD WIRTH HAP ERRELENZ HOGHES HEAD	MAPDROCK 67 TONS	CENTER 7 HUGHES TCB 11.5IN ROLLER. 2-11.5IN CONE	INTERIOR 19 HUGHES TCB 11.5IN ROLLER	GAGE B 6 HUGHES TCB R 11.5IN ROLLER	HEAD.CENTER 8.5 INTEG	1 HEAD KFTLB 150 KFTLB125	CENTER KFTLB KFTLB	KL8 630
ANCHOR PRESS KLB	MUCK SYSTEM BUCKET FROM FACE, 22FT CONVEYOR TO REAR	EM POWER SYSTEM HYDRAU.3. T POWERED BY TO 3-200HP MOTORS		GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER LASER KL8 8.45 0.09 1.7	SPACING ADVAN ET HOU	CE PER Reft. 1.7		

CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER FACTOR TOTAL L®S PRIMERS,	TRIM INTERIOR CUI
ROUND. NO. HOLES DEPTH DIAM.	
MACHINE JUHBO HACHINES	FFED LENGTH

GUIDANCE

MUCK ING

BLAST ING

BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS MITH NATURAL MOISTURE.
IMANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES*
FREE VEHICLES YES BELT CONV. YES HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES*
*POSSIBLE*TECHNOLOGY NOT FULLY DEVELOPED.

NAST-4

CURRENT: 04/01/73

GA-1

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POISSON RATIO	0.35 NOTE
YOUNGS HOD. PSIXI0E6	
****HARDNESS.* SHORE SCHMID.	24
SHORE	4 2
PCT PCT	96
COMP STRNTH KPS1	35
ORY WT PCF	161
ROCK PROPERTIES IGNEOUS: GRANITE, MASSIVE, MAJOR QUARTZ AND FELDSPAR, MINOR DARK MINERAL CONTENT,	
KEY IDENTIFICATION 5 GRANITE ADIE SAMPLE NO GA-1	

NOTES: 1. 50 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SHECIMEN. 4. INFFRRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

PCT (-) NO200 3.5 6IN. 3IN. 2IN. 17N. 1/2IN. NO4 NOB NO16 NO30 NOSO NO100 NO200 0.5 3.6 3.7 5.6 5.6 9.0 14.4 17.9 12.2 10.3 11.7 PCT (+)6 IN.SI7E 4.7 MOISTURE PCT 6.1 MUCK DATA DRY UNIT 114

SMAPE OF FRACTIONS BETWEEN SCREEN SIZES A ** ANGULAR S*SUBANGULAR R*ROUNDED P*PLATY C*CUBIC I* IRREGULAR E*E'ONGATED SP*SPHEROID

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14
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ï v

SIZE(=)2.0 IN. ANGLE INTER FRICTION DEGREES AT
IN APPARENT BULK E COMESION DENSITY PSF AT PCF AT
ANGLE/REPOSE ANGLE/REPOSE ANGLE/SLIDE IN IN DROP 10 IN DROP STEEL PLATE DEGREES AT DE
ANGLE/REPOSE ANGLE/REPOSE 10 IN DROP DEGREES AT
ANGLE/REPOSE 1 IN DROP DEGREES AT
(=)0.75 IN.SIZE SPECIF GRAVITY

0.9 PCT MOIST	9
O PCT MOIST	106
0.9 PCT MOIST 0.0 PCT MOIST	215
0.9 PCT MOIST	34
0.9 PCT MOIST 0.9 PCT MOIST	36
0.9 PCT MOIST	99
	5.59

DATA TUNNEL

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PRIMARY SECONDARY 110V POWER SYSTEM SHOTCRETE SET.SIZE.SHAPE AIN WF STEEL SETS AT 4FT. APPROX. MATER PUMP 21h UTILITY LINES A 1 8 WATER INFLOW ROOF PLATE ğ BOLT.TYPE SIZE IIN X 7FT GROUTED APPROX 35FT SUPPORT SYSTEM Ŷ 512E 221N PRESS EXHST SUPPLY EIMCO 912 LHD DIESEL VENTILATION P. X GRADE -0.22PCT PERSONNEL NONE SHAPE WORSESHOE MUCK EFMCO 917 LHD DIESEL SYSTEM HAULAGE S12E 10FT X 10FT TUNNE

MACHINE EXCAVATION

THRUST . MAX/OPERATE X X 6 5 5 CENTER TORQUE . MAX/OPERATE KFTLB KFTLB KFTLB KFTLB HEAD KERF SPACING ADVANCE PER FEET HOUR, FT. HEAD.CENTER X Q Q GUIDANCE THRUST/SO FT CUTTERS, MAKE, TYPE, DIAM, CUTTING EDGES INTERIOR POWER SYSTEM CENTER HUCK SYSTEM 3 MODEL ANCHOR PRESS MACHINE MAKE B-10

CONVENTIONAL EXCAVATION

EXPLOSIVES.
POWDER FACTOR 6.1LB/CY
TOTAL LBS 175 GELEX 2, 70PCT
PRIMERS. INTERIOR CUT LIFTERS ROUND. NO. HOLES 48 DEPTH BFT DIAM. 1-3/4IN CUT. DOUBLE V SF/HOLE 2.1 MACHINE JUMBO CRANLER MACHINES 2-093 DRIFTER FEED LENGTH 10FT

MUCKING EIMCO 912 LHD FRONT END LOADER BLASTING ELECTRICAL 0-10 REGULAR DELAYS

GUIDANCE TRANSIT

BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY: CONVENTIONAL RAIL YES SIDE RAIL YES FREE VEHICLES (3) BFLT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO POSSIBLE-TECHNOLOGY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH, WEAR, DANAGE. (3) EXCESSIVE TIPE WEAR PROBABLE.

6A-1 HDN 2

CURRENT: 04/01/73

		PCT (-) NO200	÷.	SPHEROID				ž F	
POISSON RATIO 0.31	801E	NO200		A×ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMEROID		• • • • • •		SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 2.2 PCT MOIST	;
YOUNGS MOD. PSIXIOE6	2 2 TE	NO100	~ ~	AR ERELO		TOUGHNESS	0.23		
		950	e.	I= IRREGU	₹			BULK OENSITY PCF AT 0.0 PCT MOIST	103.5
SMORE SCHMIDT	11MEN. 0043-72.	N030	0	C=CUBIC	A1	FLOW	•	MOIST 0.0	
800 EST 50	HED SPEC A.R.HO21	SCREENS	;	P=PLATY	IV IV	S6IN ICITY		STON PCT	780
COMP STRNTH KPSI 32	3. UMPOLISHED SPECIMEN. 6. FROM CSM A.R.HOZ10043-72	BETWEEN SC NOB		ROUNDED		E(-) 0.0 PLAST INDEX PCT	1.0	•	
> 1.	•		12.9 5.7	46ULAR R	, IA	PLASTIC SHRIMKAGE PLIMITS.SIZE(-) PLASTIC SHRIMKAGE IN IT PCT PCT PCT		SLIDE PLATE IS AT	32
96. PCC PCC	AD 646610-66. Imum value.	CENT BY 1	13.6	S SUBA	١٧	BERG LIN SHRIM LIMIT PCT	13.4	SIZE(-)2.0 ANGLE/SLIDE STEEL PLATE DEGREES AT 1.3 PCT MOI	es
GRAY. FINE ELY JOINTED: BANDS OF ITE AND IC GNEISS.	ROM D.U.DEERE AD 646610-6. • ASSIGNED MINIMUM VALUE.	PER CENT BY WEIGHT IN. 11N. 1/21N. NO4	13.2	A×ANGUL AF	¥	TIC IIC	•	FERTAL SI EPOSE ROP AT MOIST	
11011	r n	:	12.7	SIZES		•	17.0	ANGLE/REPOSE 10 IN UROP DEGREES AT	33
ROCK PROPERTIES 1GMEOUS: GRANITE GRAIMED: MODERAT WITH 1.S TO 2 FT LIGHT TAN PEGMAT LAMINATED GRANIT	2. INFERRED HLAR ROCK.	6IN. 3I	&	N SCREEN	~	LIGUID LIMITS PCT	•		
ROCK PROF IGNEOUS: GRAINED: WITH 1.5 LIGHT TAN	HOTES: 1. 60 PCT, OF FORMATION, 2. INFERRE! 4. INFERRED FROM TESTS/SIMILAR ROCK.	PCT (+)6 IN-SIZE	14.3	SHAPE OF FRACTIONS BETWEEN SCREEN	Ĭ		18.0	ANGLE/REPOSE 1 IN OROP DEGREES AT 1.3 PCT MOIST	0
A110M	F FORMAT	HOISTURE PCT	·•	FRACTIC		CHANGE IN.SIZE			
IDENTIFICATION HUNTER SAMPLE NO	ISI 10 PCT. O INFERRED	DATA UNIT	10 7	SHAPE OF		POT VOL CHANGE	•	(-)0,75 IN.SIZE SPECIF Gravity	2.70
* > • - • • *	MOTES: 1. 80	MUCK DRY MT	,1	_				<u> </u>	.,

B-11

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		DATA
۲. ۲	49	TUNNEL

POWER SYSTEM	PRIMARY SECONDARY 4160V 440V		SHOTCRETE 500PSI 18 HRS 3750PSI 28 DAYS 16 PCT OF 7200 FT
UTILITY LINES	AIR MATER DUMP BIN 41% 101N		SET.SIZE.SHAPE 4IN WF SETS. 4FT. 3FT. 2FT FOR 23PCT
WATER INFLOW	GP# 20-400		ROOF PLATE
VENTILATION	SHAPE GRADE CFN PRESS EXMST SIZE HP HORSESHOE •0.2SPCT 15K X 26IN 125 MODIFIED	SYSTEM SUPPORT SYSTEM	MUCK BERSONNEL SUPPLY BOLT+TYPE SIZE RAIL IN X 7FT 75LB RAIL 1 A.8 GROUTED 17PCT CY CARS, 1510M LOCOMOTIVE
TUNNEL	512E 10FT X 10FT	MAULAGE SYSTEM	MUCK RAIL. 36 75LB RAI CY CARS.

MACHINE EXCAVATION

THRUST . MAX/OPERATE		X X C C C	٠
TOROUE . MAX/OPERATE	CENTER	KF1L8 KF1L8	
TOROUE.M	HEAD	KF1LB KF7LB	ICE PER PROFT.
	HE4D.CENTER		ADVAN HOU
a o	HE4D.		KERF SPACING FEET
IG EDGES	GAGE		GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER FEET MOUR.FT.
E.DIAM.CUTTING EDGES	INTERIOR		GUIDANCE
CUTTERS.MAKE.TYPE.	CENTER		POWER SYSTEM
	-		YSTEM
	ہے		MUCK S
	MODEL		24 E S S
MACHINE	KAKE	B-12	ANCHOR PRESS MUCK SYSTEM

CONVENTIONAL EXCAVATION

HACHINE JUMBO 4 BOOM HYDROJIB HACHINES 4-CF99	ROUND. NO. HOLES 38 DEPTH 10.5FT	EXPLOSIVES, POWDER FACTOR 5.5LB/CY TOTAL LBS 200	BLASTING ELECTRICAL 0-10 REGUL
1-CF133	DIAM. 1-3/41N CUT. SPIRA! BURN	PRIMERS, GELEX 2-1 1/2 IN TRIM 20LB SMOOTHTEX 70PCT X 7/BIN	DELAYS
FEED LENGTH 12FT	SF/HOLF 2.6	INTERIOR GELEX 2-1 1/2 IN CUT GELEX 2-1 1/2 IN	
		LIFTERS GELEX 2-1 1/2 IN	

EINCO NOSE	RAIL. AIR OPERATED	
ELECTRICAL	0-10 REGULAR DELAYS	

NUCK ING

GUIDANCE LASER

BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES*
FRE VEHICLES (3) BELT CONVENTIONAL RAIL CPIPELINE NO **
POSSIBLETECHNOLOGY NOT FULLY DEVELOPED.** (1) EXCESSIVE WIDTH** WEAR** DAMAGE**
(3) EXCESSIVE TIPE WEAR PROBABLE**

CURRENT: 04/01/73

_	
P01550N RAT 10	0.35 NOTE
YOUNGS HOD. PSIX10E6	10.00 NOTE
SHORE SCHNIDT	NOTE TE
SHORE	Z
800 PCT EST	90
COMP STRN TH KPS1	39
00 41 PCF	164
ROCK PROPERTIES IGNEOUS: GRANITE GRAY, GNEISSIC, MODERATELY JOINTED.	
KEY IDENTIFICATION 7 MUNTER 5AMPLE NO	2-±
¥	

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

PCT (-)	3.3
21N. 11N. 1/21N. NO4 NO8 NO16 NO30 NO50 NO100 NO200	11.7 18.2 19.3 11.6 9.3 4.8 4.2 4.5 3.4 1.3 1.1
N030	3.4
SCREENS No16	.2 4.5
T SETWEEN NOB	4.8
BY WEIGH ZIN. NO4	9.3
PER CENT	3 11.6
N. ZIN.	18.2 19
ein. Jin.	11.7
PCT (+)6 IN-SI7E	7,3
MOISTURE PCT	3.4
MUCK DATA DRY UNIT WI POF	109

SHAPE OF FRACTIONS RETWEEN SCREEN SIZES AMANGULAR SESUBANGULAR REROUNDED PEPLATY CECUBIC INTRREGULAR EMELONGATED SPESPHEROID

	TOUGHNESS	*0.0	SIZE (+) 2.00 IN. ANGLE INTER FRICTION DEGREES AT 2.6 PCT MOIST	4
١٧	FLOW		APPARENT BULK COMESION DENSITY PSF AT PCF AT 2.6 PCT MOIST 0.0 PCT MOIST	105
¥	FLOW	3.20	BULK DENSITY PCF AT	
14	MAN Y		APPARENT COMESION PSF AT 2.6 PCT HOIS	30
¥	-) 0.056 FLASTIC INDEX PCT	0.15	:	
1∢	.5126		IN	
١,	PLASTIC SHRINKAGE FLASTICITY LIMIT LIMIT PCT PCT	11.00	ANGLE/REPOSE ANGLE/SLIDE ANGLE/SAN	38
¥	TERBE		L 512E	
¥	STIC	17.95	ATERIA REPOSE DROP S AT	
- V	FILE	1.1	ANGLE/REPOSE 10 IN DROP DEGREES AT 3.9 PCT MOIST	35
₹	Liouib LIMITS FOY	18.10	•	
14		-	ANGLE/REPOSE 1 IN DROP DEGREES AT 3.8 PCT MOIST	a,e
	CHANGE IN.SI?		+SIZE	
	POT VOL CHANGE (+)0.056 IN.SIZE	•	(*)0.75 IN.SIZE * SPECIF GRAVITY D	2.60

7-15

	DATA
(EY	7A TUNNEL

POWER SYSTEM	PRIMARY SECONDARY 4160V 480V		SHOTCRETE
UTILITY LINES	AIR WATER PUMP BIN 418 1018		SET • SIZE • SHAPE
WATER INFLOW	GPM 20-400		ROOF PLATE
	ST SIZE HP 25IN 150	SUPPORT SYSTEM	dolt.TYPE SIZE ROOF PLATE MINOR ROCK BOLT IIN X 7FT GROUTED
VENTILATION	FR PRESS EXHST		SUPPLY RAIL
	SHAPE GRADE CFM HORSESHOE +0.2SPCT AK MODIFIED	HAULAGE SYSTEM	MUCK RAIL. 36IN GAGE RAIL 75L8 RAIL. 4.8 (Y CARS. 1570N
TUNNEL	\$12E 10FT 10FT	MAULA	MUCK RAIL. 75LB

MACHINE EXCAVATION

THRUST + MAX/OPERATE		0 V V		
TORQUE.MAX/OPERATE TH	CENTER	777 7710 8		
TORQUE . M	HEAD	X7718 7718	E PER	
	HEAD.CENTER HEAD		ADVANC	
a a	HE 4D • (GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER	
IG ENGES	GAGE		THRUST/SO FT	KLB
CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	INTERIOR		GUIDANCE	
IKE•TYP			YSTEM	
CUTTERS+M/	CENTER		POWER SYSTEM	
	-		SYSTEM	
	ᆏ		S YOUR	
	MODEL		PRESS	
HACHINE	MAKE	B-14	ANCHOR PRESS MUCK SYSTEM	۲.6 درو

CONVENTIONAL EXCAVATION

HYDROJIB NO. HOLES 36-40 99 DEPTH 11FT 133 DIAM. 1-3/4IN CUT. SPIRAL BURN 2FT SIN CENTER HOLE	
F/HOL	V i

GUIDANCE LASER

MUCKING EIMCO NO25 RAIL. AIR OPERATED

AASIS FOR WDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE,
TRANSPOPT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES*
FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO
POSSIBLE:TECHNOLOGY NOT FULLY DEVELOPED (1) EXCESSIVE WIDTH* WEAR* DAMAGE*
(3) EXCESSIVE TIRE WEAR PROBABLE*

H-2 H0N 2

CURRENT: 04/01/73

POISSON RATIO	0.33
YOUNGS MOD. PSIX10E6	
SHORE SCHWIDT	9
SHORE	4
AGD PCT	0
COMP STRNTH KPS1	53
DRY ET PCF	162
ROCK PROPERTIES IGNEOUS: GRANITE GNEISS, MODERATELY JOINTED, THREE INTERSECTING SETS OF	45 DEG. TO VERTICAL
KEY IDENTIFICA: ION 51 HUNTER SAMPLE NO	£ -1

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HO210043-72. AT 4 IN. TO 2 FT.

PCT (-) NO200	6.
**:PER CENT BY WEIGHT BETWEEN SCREENS	1:1
NO 11 ON	12.0 9.9 9.9 7.5 3.5 2.9 2.9 2.3 2.3 1.1
NO 50	2.3
NO30	5.9
SCREENS No16	6.5
BETWEEN NOB	3.5
WE I GHT NO4	7.5
CENT BY	6.6
PER 111N.	6.
6IN. 3IN. 2IN.	11.4 12.0
PCT(+)5 IN.SIZE	32.5
MOISTURE PCT	2.0
MUCK DATA DRY UNIT	104

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AFANGULAR SESUBANGULAR REROUNDED PEPLATY CECUBIC INTRREGULAR CELLONGATED SPRSPHEROID

B-15

	PLASTIC SHRINKAGE PLASTCITY FLOW TOUGHNESS LIMIT LIMIT PCT PCT	0.11	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT	43.50
¥.	X	3.80	APPARENT BULK COMESION DENSITY PSF AT PCF MOIST 4.46 PCT MOIST	98.9
I	130	e.	PCF	
•	561N		INAPPARENT COMESION PSF AT IST 4.46 PCT HOIS	٥
14	PLAST INDEX PCT	0.40	4 0 d	
I V	S 512E (-		IN IDE ATE AT MOIST	20
41	BERG LIMIT SHRINKAG LIMIT FCT	16.65	ANGLE/REPOSE SIZE(-)2.0 IN ANGLE/REPOSE ANGLE/SLIDE 10 IN DROP STEEL PLATE DEGREES AT DEGREES AT 4.46 PC1 HOIST 4.46 PCT HOIST	31.50
Ā	ATTER		AL SI E ST	
١٧	ISTIC	16.80	ATERI PROP UROP S AT	35
I W		2	ANGLE/REPOSE 10 IN UROP DEGREES AT	35,35
¥	J10 T5	2		
~	HANGE LIOUID IN.SIZE LIOUID PCT	17,20	() 0.75 IN.SIZE ************************************	38.50
	POT VOL CHANGE (-)0.056 IN.SIZE	0	(+)0.75 IN SPECIF GRAVITY	2.497

04/01/73

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BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENITONAL RAIL YES SIDE RAIL YES*
FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO POSSIBLE,TECHNOLOGY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH, WEAR, DAMAGE.
(3) EXCESSIVE TIPE WEAR PROBABLE.

04/01/73

GUIDANCE LASER

	PCT	,			-		ROUP NO. DEPT CUTA
	68ADE +0.25P(PERSONNEL Rail		7	SYSTEM	NOI	GEODO N
	SHOE IED	STEM 1 646E 4.8	EXCAVATION	MODEL	PRESS MUCK	ONAL EXCAVATION	NE 4 800M HYDRO NES 4-CF93 1-PR123 LENGTH 12FT
TUNNEL	\$12E 10FT X10FT	HAULAGE SY MUCK AAIL. 36IN 75LB RAIL. CY CARS. B	MACHINE	MACHINE B-16	ANCHOR KL8	CONVENT	MACHINE JUMBO 4 MACHINES

THRUST . MAX/OPERATE

SECONDARY 480V

PRIMARY 4160V

PU'1P 12:1N

UTILITY LINES AIR WATER 10IN 4IN

WATER INFLOW

20 S

#P 220

S12E 261N

PRESS EXHST

CFE 6K

VENTILATION

DATA

51A TUNNEL KEY

SHOTCRETE 3 IN TO 4 IN TH 36 PCT X 22K FT

SET.SIZE.SHAPE 4 IN WF 10 PCT X 22K FT.

ROOF PLATE

BOLT.TYPE SIZE
1 IN X 7 FT
GROUTED
9PCT X 22KFT

SUPPLY RAIL

SUPPORT SYSTEM

POWER SYSTEM

MACHINE		CUTTERS+MAKE+TYPE+DIAM+CUTTING EDGES	.DIAM.CUTTIN	G EDGES	N OC		TORQUE . MAX/OPERATE	OPERATE
MAKE MODEL	7	CENTEP	INTERIOR	GAGE	HEAD.	HEAD.CENTER	HEAD	CENTER
B _16							KF1LB KF1LB	KF118 KF118
ANCHOR PRESS MUCK SYSTEM KLB	SYSTEM	POJER SYSTEM	GUIDANCE	THRUST/SO FT KLB	GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER FEET HOUR.FT.	ADVANCE HOUR.	4 t.	
CONVENTIONAL EXCAVATION HACHINE JUMBO 4 BOOM HYDRO MACHINES 4-CF93 1-PR123 FEED LENGTH 12FT	Z O	ROUND. HOLES 40 DEPTH 11FT DIAM. 1.75 IN. CUT. SPIRAL BURN SIN CENTER HOLE SF/HOLE 2.6		EXPLOSIVES, POWDER FACTOR S.BLB/CY TOTAL LBS 225 PRIMERS, OELEX 2.75PCT TRIM 30 PCT. 7/8 X 24 IN. INTERIOR GELEX 2. 75 PCT CUT GELEX 2. 75 PCT LIFTERS GELEX 2. 75 PCT	/CY PCT 24 IN. 5 PCT	BLA PLA DEL	BLASTING ELECTRICAL 0-10 REGULAR DELAYS	MUCKING EINCO NO25 Air Oper.

R	 1

••	A=ANGULA!' S*SUBANGULAR R=ROUNDED P=PLATY C*CUBIC I=IRREGULAR E*ELONGATED SP*SPHEROID		•		12E(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT	
0.1	AR E=ELONG		TOUGHNESS	0.30	SIZE ANG FRIG OEG	63
e. J	I= JAREGUL	A1	. X		ULK ENSITY CF AT 0 PCT MOIST	97.3
0.3	C=CUBIC	!	FLOW	3,90	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
4.0	PL ATY	14	NI YE		APPARENT COHESTON PSF AT 0.4 PCT HOIST	435
9.0	JUNDED P.	I	-) 0.056 PLASTIC INDEX PCI	0.12		
0.7	AR R=RO	A1	••S1ZE (1N.	
2.0	s*SUBANGUL	¥	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	17.69	SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 0.8 PCT MOIST	2
3.8	VOLA!" S	١٧	TTERBE		SIZE	
5.0		14	STIC	17.98	ANGLE/REPOSE 10 IN DROP DEGREES AT 0.8 PCT MOIST	
5.9	SIZES	١٧	PLA LIN PCT	11	ANGLE/M NO IN DEGREE	36
13.8	N SCREEN	¥	LIOUID LIMITS PCT	18.10	:	
66.8	SHAPE OF FRACTIONS BETWEEN SCREEN SIZ	µ• ≪		38.	ANGLE/REPOSE 1 IN DROP DEGREES AT 0.8 PCT MOIST	33
7.0	OF FRACT		POT VOL CHANGE (-)0.056 IN.SIZE		(-)0.75 IN.SIZE SPECIF GRAVITY	
102	SHAPE		POT V	0	SPECII GPAVI	2.85

PCT (-) NG200

61N. 31N. 21N. 11N. 1/21N. NO4 NO8 NO16 NO30 NOSO NO100 NO200

PCT (+)6 IN.SIZE

MOISTURE PCT

MUCK DATA DRY UNIT WI PCF

NOTES: 1. 90 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UMPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZIOO43-72.

POISSON RATIO

YOUNGS MOD. PSIX10E6

SHORE SCHMIDT

PCT ESI

COMP STRNTH KPSI

ORY PCF

ROCK PROPERTIES IGNEOUS, BIGITITC QUARTZ MGNZONITE, FINE TO MEDIUM GRAINED PORPHYRY,

KEY IDENTIFICATION 8 LK

SAMPLE NO LK-1 0.70 NOTE

8.80 NOTE

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BA TUNNEL DATA

POWER SYSTEM	PRIMARY SECONDARY 4160V 220V		SHOTCRETE
UTILITY LINES	AIR WATER PUMP 6IN 2IN		SET+SIZE+SHAPE
WATER INFLOW	GPM NONE		ROOF PLATE 13.5IN X 9FT
	SIZE HP 48IN 150	SUPPORT SYSTEM	BOLT-TYPE SIZE ROOF PLATE 3/4in x 6ft, 13.5in x 9ft at 4ft
VENTILATION	CFM PRESS EXHST 76K HEAD SURF		SUPPLY 01ESEL TRUCK
VE	6RADE <5.5PCT		PERSONNEL DIESEL TRUCK
TUNNEL	SIZE SHAPE 18FT X ARCHED 16FT BACK	HAULAGE STOTEM	MUCK WAGNER ST-8 SCOOPTRAM. RAIL SKIP

MACHINE EXCAVATION

MACHINE			CUTTERS.MAKE.TYPE.	PE.DIAM.CUTTING EDGES	NG EDGES	A A	2	TORQUE . MAX/OPERATE	THRUST . MAX/OPERATE
HAKE	HODEL	3	CENTER	INTERIOR	GAGE	HEAD . CENTER	ENTER HEAD	AD CENTER	
B-18							A A	KFTLB KFTLB KFTLB KFTLB	77 00
ANCHOR PRESS MUCK SYSTEM)OM SS:	CK SYSTEM	POWER SYSTEM	GUIDANCE	THRUST/SO FT KLB	GUIDANCE THRUST/SQ FT KERF SPACING ADVANCE PER FEET HOUR.FT.	ADVANCE P HOUR .FT	α.	

CONVENTIONAL EXCAVATION

MACHINE	ROUND.	EXP_USIVES.	BLASTI
JUMBO 3 800M	NO. HOLES 47	PraDER FACTOR 4.0 LB/CY	ELECTA
MACHINES GARDNER DENVER	ER DEPTH 10.5FT	,0TAL LBS 365	0-15 R
1-PR123	DIAM. 1-3/4IN	PRIMERS, 25LB 1.5IN X BIN, 60-75PCT	DELAYS
2-54123 DR1F1	2-54123 DRIFTER CUT. 6 HOLE BURN	TRIM 25LB 7/8IN X 16IN. 30PCT	1
FEED LENGTH 12FT	1-4IN CNTR HOLE	INTERIOR ANFO	
	SF/HOLE 5.2	CUT 40LE 1.5IN X 16IN. 45PCT	
		LIFTERS ANFO	
BASIS FOR	MON IS DRY SCREEN ANALYSIS	AFTER WASHING UNLESS	
NOTED BY	IN) FOR SCREEN ANALYSIS WITH	H NATURAL MOISTURE.	
TRANSPORT	SYSTEM CAPABILITY:CONVENTION	ONAL RAIL YES SIDE RAIL YES+	
FREE VEHIC	LES (3) BELT CONV. (1) HYD!	FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO	0
*P05518LE	TECHNOLOGY NOT FULLY DEVEL	DPED. (1) EXCESSIVE WIDTH: WEAR. DAMAGE.	
(3) EXCESS	(3) EXCESSIVE TIRE WEAR PROBABLE.		

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CURRENT: 04/01/73

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NUCKING SCOOP TRAN

		-	PCT (-)	1.3	**SPHEROID				O IN. TER AT Moist	
P01550N RATIO	0.33 NOTE		NO200		SNGATED SF		• • • • • • • • • • • • • • • • • • • •		SCT IN	39
YOUNGS MOD. PSIX10E6	9.40 NOTE		NO100	8.0 8.0	HAR ETELC		TOUGHNESS	0.058		
	56 NOTE 2	•	NO30 NOSO NO100 NO500	. 0	: I=IRREGU	14	INDEX	Ŋ	BULK DENSITY PCF AT 3.0 PCT HOIST	97.6
SHORE SCHMIDT	₹ 2	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.H0210043-72.	N030	.3 1.0	Y C*CUBIC	I	•	6.2) 1SIO	
ROD FST	83	.ISHED SP Sh A.R.HO	SCREENS NO16	1.8 1.	ED P=PLAT	17 VI) 0.056IN. PLASTICITY INDEX PCT	. 0	APPARENT COHESION PSF AT	210
COMP STRNTH KPSI	82	3. UNPOL	DETAEEN NOB	2.0	R=ROUND		SIZE(-) 0 PLA IND PCT	0.36		
ORY WT PCF	165	•	PER CENT BY WEIGHT ZIN. 11N. 1/21N. NO4	5.3	S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMEROID	¥	PLASTIC SHRINKAGE PLANTS.SIZE(-) PLASTIC SHRINKAGE IN LIMIT LIMIT PCT	17.29	L SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT T A.7 PCT MOIST	33
QUARTZ O MEDIUM WITH MINOR	• 6	H D.U.DEERE AD 646610-6 ASSIGNED MINIMUM VALUE.	21N. 11N.	5.8 5.5	A=ANGULAR	AI AI	STIC	19.14	ANGLE/REPOSE 10 IN DROP DEGREES AT	
•	LINED JOINIS.	5.	61N. 31N. 2	16.9 8.7	EEN SIZES	AI AI		61	ANGLEN 10 IN DEGREE	45
GOCK PROPERTIES IGNEOUS: BIOTITIC HONZONITE, FINE TO GRAINED PORPHYRY.	STEEPLY INCLINED	NOTES: 1. 80 PCT, OF FORMATION. ?. INFERRED 4. INFERRED FROM TESTS/SIMILAR ROCK.	PCT(+)6 *** IN.SIZE 6IN	49.1	FRACTIONS BETWEEN SCREEN		LIGUID LIMITS PCT	20.50	ANGLE/REPOSE 1 IN DROP DEGREES AT	
A110%		OF FORMATION.	HOISTURE PC	1.6 49	FRACTIONS	Ą	POT VOL CHANGE (-)0.056 IN.SIZE		IN.SIZE ***. ANGL 1 IN DEGR	4 3
IDENTIFICATION LK SAMPLE NO	LK-2	NOTES: 1. 80 PCT. 0 4. INFERRED	HUCK DATA ORY UNIT W	103	SHAPE OF		POT VOL.	٥	(-)0.75 I	2.73
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GUIDANCE LASER

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STEM	PRIMARY SECONDARY 4160V 220V		
POWER SYSTEM	PRIMARY 4160V		SHOTCRETE
UTILITY LINES	AIR WATER PUMP 6IN 2IN		SET.SIZE.SHAPE
WATER INFLOW	GPM		ROOF PLATE 13.5IN X 9FT
	051 NI85	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE 3/4in x 6ft 13.5in x 9ft at 4ft
VENTILATION	CFM PRESS EXHST 22K HEAD SURF		SUPPLY DIESEL TRUCK
7	GRADE +2.0PCT		PERSONNEL Diesel Truck
TUNNEL	SIZE SHAPE 18FT X ARCHED 16FT BACK	HAULAGE SYSTEM	MUCK MAGNER ST-8 SCOOPTRAM+ RAIL SKIP

MACHINE EXCAVATION

THRUST + MAX/OPERATE		مر د د د	
TORQUE+MAX/OPERATE	CENTER	XFTL8 XFTL8	
TORQUE .M	HEAD.CENTER HEAD	KFTLB KFTLB	VANCE PER Hour.ft.
APA	HEAD+CE!		GUIDANCE THRUST/SQ FT KERF SPACING ADVANCE PER FEET HOUR,FT.
NG EDGES	GAGE		THRUST/SO FT KLB
PE.DIAM.CUTT	INTERIOR		
CUTTERS.MAKE.TYPE.DIAN.CUTTING EDGES	CENTER		POWER SYSTEM
	¥		K SYSTEM
	HODEL		ANCHOR PRESS MUCK SYSTEM KLG
MACHINE	MIKE	B-20	ANCHOR PI

CONVENTIONAL FXCAVATION

MUCKING SCOOPTRAM	1 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
BLASTING ELECTRICAL 0-15 REGULAR DELAYS	Q .
EXPLOSIVES. POWDER FACTOR 4LB/CY TOTAL LOS 365 PRIMERS. 25LB 1.5IN X BIN. 60-75PCT TRIM 25LB 7/8IN X 16IN. 30PCT INTERIOR ANFO CUT 40LB 1.5IN X 16IN. 45PCT LIFTERS ANFO	PASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UMLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES. FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO *POSSIBLE*TECHNOLOGY MOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH. WEAR. DAMAGE. (3) EXCESSIVE TIRE WEAR PROBABLE.
MACHINE JUMBO 3 BOOM NO. MOLES 47 MACHINES GARDNER DENVER DEPTH 10.5FT 3-PR123 DAIFTER DIAM. 1-3741N CUT. 6 MOLE BURN FEED LENGTH 12FT SF/HOLE 5.2	HASIS FOR MON IS DRY SCREEN ANALYSIS NOTED BY (N) FOR SCREEN ANALYSIS WITH TRANSPORT SYSTEM CAPABILITY:CONVENTIO FREE VEHICLES (3) BELT CONV. (1) HYDR *POSSIBLE:TECHNOLOGY MOT FULLY DEVELO (3) EXCESSIVE TIRE WEAR PROBABLE.
MACHINE JUMBO MACHINE FEED LE	

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SAMPLE NO				PCT (-) NO200	11.0	SPHEROID	•		* *	
ENTITICATION ROCK PROPERTIES. THE TO WEDLIN FOR THE STREAM POT SHORE SCHILL NOD MONZONITE. FINE TO WEDLIN FOR THE STREAM POT SHORE SCHILL NOD MONZONITE. FINE TO WEDLIN FOR THE STREAM POT SHORE SCHILL NOD MONZONITE. FINE TO WEDLIN FOR THE STREAM POT STRE	POISSON	0.32 NOTE		•		IGATED SP#!	•			
DETAIL ON BOCK PROPERTIES LIGHEOUSE BIOTITIC QUARTZ HONZONITE, FINE TO WEDIUM GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY LIGHT HOISTURE PCT(*)6 ***********************************	YOUNGS MOD. PSIX10E6	9.00 NOTE		NO100	0 • vi	LAR E=ELON	:	0.73		
DETAIL ON BOCK PROPERTIES LIGHEOUSE BIOTITIC QUARTZ HONZONITE, FINE TO WEDIUM GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY LIGHT HOISTURE PCT(*)6 ***********************************	ONESS SCHM1DT	3	សំ	V90N		1=1RREGU	<	95*	ASITY PCT	
DETAIL ON BOCK PROPERTIES LIGHEOUSE BIOTITIC QUARTZ HONZONITE, FINE TO WEDIUM GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY LIGHT HOISTURE PCT(*)6 ***********************************	SHORE	Z Z	PECIMEN.	DEON		Y CECUBIC		<i>u</i> n	0 181 0	
DETAIL ON BOCK PROPERTIES LIGHEOUSE BIOTITIC QUARTZ HONZONITE, FINE TO WEDIUM GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY LIGHT HOISTURE PCT(*)6 ***********************************		26	LISHED SP SM A.R.HO	SCREENS. NO16		O PEPLAT	L 056IN.	Ñ	PARENT FS TON	
DETAIL ON BOCK PROPERTIES LIGHEOUSE BIOTITIC QUARTZ HONZONITE, FINE TO WEDIUM GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY LIGHT HOISTURE PCT(*)6 ***********************************	COMP STRNTH KPSI	35	3. UNPO			REROUNDE	SIZE(~) G	4	NI 52	
DETAIL ON BOCK PROPERTIES LIGHEOUSE BIOTITIC QUARTZ HONZONITE, FINE TO WEDIUM GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY LIGHT HOISTURE PCT(*)6 ***********************************	ORY PCF	165	•	87 WEIGHT ZIN. NO4	20.0	SUBANGUL AR	FI FINITS. FRINKAGE IMIT	19.68	-)2.0 GELC/SLIDE FEL PLATE GREES AT PCT MOI:	
DENTIFICATION ROCK PROPERTIES IGNEOUS: BIOITIC MONZONITE. FINE T MONZONITE. FINE T GRAINED PORPHYPY GRAINED PORPHYPY GRAINED PORPHYPY S: PCT. OF FORMATION. 2. INFERED FRI WEERED FROM TESTS/SIMILAR ROCK. 5. DATA UNIT MOISTURE PCT(*)6 ***********************************	_			PER CENT			ATTERBERC SPECIFIC	~	IST IST	
DENTIFICATION ROCK PROPERTIES LIGNEOUS: BIOTII MONZONITE. FINE LIGUID LIMITS PCT MONZONITE MONZONIT	C QUARTZ TO MEDIUM		ROM D.U.D	N. ZIN.	•	532		20.95	MATERI VGLE/REPOS IN DROP GREES AT	
DENTIFICATION AMPLE NO A=5 S: S-C. OF FORMATION WERRED FROM TESTS. DATA UNIT MOISTURE PA PCF PCT IS HAPE OF FRACTIONS HAPE OF FRACTIONS OT VOL CHANGE -) 0.056 IN.SIZE ANGE RAVITY 1 IN DECIF ANGE RAVITY DECIF 1 ANGE 3.44 3.44	ROPERTIES S: BIOTITI (TE+ FINE) PORPHYPY		۵	•	0.0	SCREEN S	•	90	ļ	
SAMPLE NO LK-5 SAMPLE NO LK-5 HO PCT, OF FORMATI INFERRED FROM TEST INFERRED FROM TEST SK DATA Y UNIT MOISTURE POF PCT PCF PCT PCF PCT PCF PCT O 0055 IN-SIZE (-)0.055 IN-SIZE (-)0.056IN-SIZE SPECIF GRAVITY I AN	ROCK PE IGNEOUS HONZONI GRAINED		ION. 2. I	PCT(+)6 IN.SIZE	0 • 0	IS BETWEEN		25.1	GLE/REPOSI IN DROP GREES AT	
SAMPLE NI LK-5 SAMPLE NI LK-5 B0 PCT. (INFERRED SY UNIT N PCF F PCF F P	CATION		FROM TEST		& • 8	FRACTION	CHANGE IN.SIZE			
	DENTIFIC		FES: 80 PCT. O INFERRED	DATA UNIT POF		SHAPE OF	POT VOL (→) 0.055	٥	(~)0.056If SPECIF GRAVITY	

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FOREST DE CONTRACTOR DE CONTRA		EN	PRIMARY SECONDARY 440V		
- orași		POWER SYSTEM	IMARY S		el El
· · · · · · · · · · · · · · · · · · ·		0	a.		SHOIL ETE
Polyveet 1			£		
because 5		UTILITY LINES	AIR WATER PUMP NA		NONE NONE
Property S		UTILIT	Z Z		SET•SI NONE
Prince A		INFLOW			LATE
To the second se		WATER INFLOW	GPW NONE		ROOF PLATE
The state of the s			£	SUPPORT SYSTEM	NONE SIZE
			321S	SUPPOR	BOLT.T.
mas S		NO.	PRESS EXHST NONE		SUPPLY DIESCL TRUCK
		VENTILATION	CFM PRE RONE		SUP DIE TRU
		7	GRADE CF Vert RC		PEPSONNEL OTESEL TRUCK
				.	PER 016 1Ru
`	DATA		SIZE SHAPE 12FT ROUND 13-7/BIN PILOTHOLE	HAULAGE SYSTEM	R ST-8
	KEY 10a TUNNEL DATA	TUNNEL	S12E 12F T 13-7/8	HAULAG	MUCK WAGNER ST-8 SCOOPTRAM RAIL SKIP

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HACHINE		CUTTERS.MAKE.TYP	CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES		APK	TORQUE, MAX/OPERATE	OPERATE	THRUST . MAX ZOPERATE
R-55 ROBBINS B-25	MODEL WT HBIR RAISE 49 Drill Tons	CENTER 1 ROBBINS 11IN 51L DISC+2-11IN	INTFRIOR GAGE HEAD.CENTER HEAD 19 ROBRINS 121N 3 ROBBINS, 121N 6 INTEG KFTLB STEEL DISC.2-11 STEEL DISC IN TWIN STEEL STEEL DISC.	EL DISC	HEAD.CENTER 6 INTEG	HEAD KF7LB 583 KF7LB 260	CENTER KFTLB KFTL9	KLB 814 KLR 490-
ANCHOR PR	ANCHOR PRESS MUCK SYSTEM GRAVITY KLB	POWER SYSTEM ELECTRIC MOTORS 3-100 HP	GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER SURVEY IN PILOT KLB 3.64 0.25 2.7 HOLES	OFT KERF SP. FEET	ACING ADVANC	E PER		

CONVENTIONAL EXCAVATION

MUCKING	7.3 6.7 8.5 8.5
BLASTING	IE YES• 1848LE•
EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT	BASIS FOR MDW IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL WOISTURF. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES YES BELT CONV. (2) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE YES* *POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
ROUND. NO. HOLES DEPTH DIAM. CUT.	BASIS FOR MDW IS DRY SCREEN AND NOTED BY (N) FOR SCREEN ANALYSI TRANSPORT SYSTEM CAPABILITY:CONFREE VEHICLES YES BELT CONV. (2 PPCSSIBLE,TECHNOLOGY NOT FULLY
MACHINE JUMBO MACHINES FEED LENGTH	

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PCT (-) NO200	16.0	P.S.PEROID				
ZIN. 11N. 1/21N. NO4 NOB NO16 NO30 NO50 NO100 NO200	0.	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAP R=20UNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPEROID		TOUGHNESS Index	0.31	SIZE(=) 2.0 I ANJLE INTER FRICTION DEGREES AT 0.2 PCT MOIST
NOSO NO	7.0	I=IRREGULA	∢		•	BULK DENSITY PCF AT 0.0 PCT HO1ST
030	0.0	*CUBIC	⋖	FLOW	4.00	
EENS 016 N	11.0 11.0	*PLATY C	◀	:		APPARENT COMESION PSF AT 0.2 PCT HOIST
WEEN SCR		OUNDED P	∢	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	1.24	
GHT BET 04	19.0 12.0	LAP R=2	∢	5512E		IN IDE ATE AT HOIST
T BY WEI	19.0	=SUBANGU	∢	RG LIMIT SHRINKAG LIMIT PCT	17.27	SIZE(-) 2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 3.7 PCT HOIST
PER CEN	0*6	SULAR S	⋖	TTERBE		
ZIN. 1	0.0 1.0 9.0	A=ANG	¥	PLASTIC LIMIT PCT	18.16	ANGLE/REPOSE 10 IN UROP DEGREES AT 1.7 PCT NOIST
JIN.		4 S12ES		PLAS LIM	Ä	ANGLE/REPOS NO IN DROP DEGREES AT 3.7 PCT MOI
6in. 3in.	0.0	SCREEN		Liguid Limits PCT	19.40	
PCT(+)6 IN.SIZE	0.0	S BETWEEL		• 1116	19,	ANGLE/REPOSE 1 IN DROP DEGREES AT 3.7 PCT HOIST
MOISTURE P) 8•91	F FRACTIONS		POT VOL CHANGE (*) 0.056 IN.SIZE		IN.SIZE AND AND AND BEG
MUCK DATA DRY UNIT	96	SHAPE O		POT VOL.	•	(+) 0.751N.SIZE Specif Gravity
x		n	23			

POISSON RATIO

SHORE SCHMIDT

PCT PCT EST 86

ORY WI PCF

ROCK PROPERTIES
IGNEOUS: BIGITIC QUARTZ
HONZONITE. FINE TO MEDIUM
GRAINED PORPHYRY. FREQUENT
FLAT ANGLED JOINTS.

IDENTIFICATION LK

KET 11 SAMPLE NO

COMP STRNTH KPSI 3 SINGLE SPECIMEN L/R = 1,3

0.20 NOTE

20 NOTE

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZIOO43-72.

YOUNGS MOD. PSIX10E6 1.50 NOTE

04/01/73	
CURRENT:	
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GUIDANCE

MUCK ING

BLASTING

HERE SAME AND THE SAME SAME SAME SAME SAME SAME SAME SAM		HP GPM AIER PUMP PRIMARY SECONDARY NONE NA MATER PUMP PRIMARY SECONDARY		BOLT+TYPE 517E ROOF PLATE SET+SIZE+SMAPE SMOTCRETE NONE		ING EDGES RPM TORQUE.WAX/OPERATE THRUST.MAX/OPERATE	GAGE HEAD.CENTER HEAD CENTER KLB 121N I ROBBINS 121N 6 INTEG KFTLB 583 KFTLB KLB TWIN STEEL KFTLB 2-0 KFTLB CO	THRUST/SQ FT KERF SPACING ADVANCE PER FEET HOUR.FT. 1 KLB 17.2 0.13 4.8
	ALITICATION	PRESS EXHST SIZE NONE	SUPPORT SYSTEM	SUPPLY BOLT+TYPE DIESEL NONE TRUCK		CUTTERS.HARE.TYPE.DIAM.CUTTING EDGES	CENTER INTERIOR 1 ROBRINS 12IN 4 ROBRINS 12IN 5TEEL DISC TWIN STEEL DISCS	POWER SYSTEM GUIDANCE ELECTRIC SURVEY MOTORS IN PILOT
TUNNEL DATA	TUNNEL	SIZE SHAPE GRADE CFM 4FT ROUND VERT 13 7/8IN PILOTMOLE	HAULAGE SYSTEM	MUCK WAGNER ST-8 DIESEL SCUOPTRAM TRUCK RAIL SKIP	MACHINE FXCAVATION	MACHINE	HAKE MODEL HT CENTROBENS HOBEL HOBEL HOBENS ORILL TONS STEEL	ANCHOR PRESS MUCK SYSTEM GRAVITY KLB

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CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS,	INTERON. CUT LIFTERS
ROUND. NO. HOLES DEPTH DIAM.	• 100
HACHINE JUMEO MACHINES	FEED LENGTH

BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAII YES*
FREE VEHILES YES BELT CONV. (2) HYDRAULIC PIPELINE YES PAEUMATIC PIPELINE YES*
*POSSIBLE·TECHHOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.

LK-6 HDN 6

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LK-7

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114

70

88

56

SIZE(-) 2.0 IN ANGLE INTER FRICTION DEGREES AT 0.2 PCT MOIST AT PCT MOIST ESION DENSITY AT PCF AT PCT MOIST 0.0 PCT COHESION PSF AT 0.2 PCT M 10 IN DROP DEGREES AT 1.7 PCT MOIST

APPARENT BULK L SIZE(~)2.0 IN ANGLE/SLIDE STELL PLATE DEGREES AT 1 1.7 PCT MOIST ANGLE/REPOSE ANGLE/REPOSE
1 IN DROP
DEGREES AT
1.7 PCT MOIST

SPECIF GRAVITY

17.04 17.12 18.00

TOUGHNESS

FLOW

PLASTIC SHRINKAGE PLASTICITY
LIMIT LIMIT PCT
PCT

LIQUID LIMITS PCT

POT VOL CHANGE (-) 0.056 IN.SIZE

0.18

2.00

0.88

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2.68

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHEROID

1.2 . 3,7 4.3 14.2 15.5 14.0 11.2 12.3

PCT (-) 4.3 PCT(+)6 IN-SI7E 13.1 MOISTURE PCT 8.7 MUCK DATA ORY UNIT 107

NOTES: 1. 80 PCI. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMEU SPECIMEY. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

SHORE SCHWIDT PCT EST ř COMP STRNTH KPSI PCF ROCK PROPERTIES
GMOUSS: QUARTZ MONZONITE
PORPHYRY: INTENSELY ALTERED
COAPSE GRAINED SAMPLE NO

IDENTIFICATION LK

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POISSON RATIO

PSIX10E6 YOUNGS

0.10

4.76

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CURRENT: 04/01/73
LK-7 MDN 2
BASIS FOR ME IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL WOISTUNE. TRANSPORT SYSTEM SARBILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELIME NO *POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH: WEAR: DAMAGE. (3) EXCESSIVE TIRE WEAR PROBABLE.

	STEN	SECONDARY 220	·	THRUST • MAX/OPERATE	X X 21 21 20 20		GUIDANCE LASER
	POWER SYSTEM	PRIMARY 4160	SHOTCRETE	K/OPERATE	X X X X X X X X X X X X X X X X X X X		MUCKING SCOOPTRAM
	UTILITY LINES	WATER PUMP 21% 41%	SET.SIZE.SHAPE		HEAD.CENTER HEAD KFTLB KFTLB	ADVANCE PER HOUR•FT•	BLASTING ELECTRICAL 0-15 REGULAR DELAYS
		AIR		G.	HEAD.	KERF SPACING FEET	/CY 1N+ 60PCT 30PCT
	WATER INFLOW	GPM HINOR	ROOF PLATE 13.51NK9FT	9.390	GAGE	UST/S0 FT	EXPLOSIVES. POWDER FACTOR 4.7 LB/CY TOTAL LBS 350 TRIMERS. 25LR. 1.5X8IN. 60PCT TRIM 25LB.7/8X!6IN. 30PCI INTERIOR CUT
		SIZE HP 48IN 150	SUPPORT SYSTEM BOLT.TYPE SIZE 6F1X3/41N#4FT	*DIAM*CUTTING EDGES	INTERICA	GUIDANCE THR	EXPLOSIVES. POWDER FACTOR TOTAL LRS 350 PRIMERS. 25LR TRIM 25LB.7/8 INTERIOR CUT
	VENTILATION	PRESS EXHST	SUPPLY DIESEL TRUCK	CUTTERS+MAKE+TYPE+	CENTER	POWER SYSTEM	ROUMD. MO. HOLES 42 DEPTH 10.5 DIAM. 1.75 CUT. BURN SF/HOLE 4.7
	7	GRADE CTM	PERSONNEL DIESEL TRUCK		(i)	MUCK SYSTEM	
L DATA		SHAPE X ARCHED 1 9ACK	SYSTEM ST-8 ST-8	MACHINE EXCAVATION MACHINE	(E MODEL	40R PRESS	COMVENTIONAL EACAVATION HACHINE JUMBO 3 BOOM HACHINES PR-123 FEED LENGTH 12FT
124 TUNNEL		512E 15F1 x 14 F1	HAULAGE S' MUCK WASNER ST SCOOP TRAI	MACHINE	₩ ₩ B-2		CONVENT MACHINE JUMBO MACHINE FEED LE

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KEY

		PCT (-)	2 - 2	SPHEROID				ž Ž		
7.54 0.20			0.7	A≈ANGULAR S≈SUBANGULAR R≈ROUNDED P≈PLATY C«CUBIC I=IRREGULAR E≈ELONGATED SP≈SPHEROID		TOUGHNESS	62.0	SIZE(+) 2.0 II ANGLE INTER FRICTION DEGREES AT 0.2 PCT MOIST	;	04/01/73
47 7.		050 NO10	7.0	=IRREGULAR	∢	•		SITY AT PCT MOIST	112	CURRENT: 04.
4 Z	CIMEN.	2 0002	1. 1.	r c=cuBIC I	⋖	FLOW		BULK BULK DENS PCF DIST 0.0		Š
90	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.H0210043-72.	N SCREENS.	3.0 2.2	10ED P#P[AT]	< <	0.056IN LASTICITY WDEX	1.48	APPARENT COMESION PSF AT 0.2 PCT E	Q6	3 X S
61	66. 3. UNP . 6. FROM	IGHT BETWEE NO4 NO8	6.5	ULAR R=ROUN	•	1551ZE(-) 6E 1	-	1N		
165	AD 646610-	CENT BY WE	17.0 14.0	R S≖SUBANG	∢	RRERG LIMI SHRINKA LIMIT PC,	10.52	SIZE(-)2.0 ANGLE/SLIDE STEEL PLATE DEGREES AT 0.2 PCT NOI	28	
• PRONOUNCED ING	FROM D.U.DEERE AD 646610-66. 5. ASSIGNED MINIMUM VALUE.	M. ZIN. 11N. 1/ZIN. NO4 NO8 NO16 NO30 NO50 NO100 NO700	3.7 14.8 1		ط ط	PLASIC SMRINKAGE PER LIMITS.SIZE(-) PLASIC SMRINKAGE PER LIMIT LIMIT PC, PC,	11.02	ANGLE/KEPOSE 10 IN DROP DEGREES AT	31	
HIGHLY FRACTURED.PRONOUNCED ORTHOGONAL FAULTING		6	10.8	EEN SCREEN S	∢	LIQUID LIMITS PCT	12,50	-		
HIGH	NOTES: 1. 80 PCI. OF FORMATION. 2. INFERRED 4. INFERRED FROM TESTS/SIMILAR ROCK.	TURE PCT(+)6 IN-S17E	23.5	SHAPE OF FPACTIONS BETWEEN SCREEN SIZES	∢	321		ANGLE/RE 1 IN DRC DEGREES	36	
S#~1	: PCI. OF F(FFPRED FROM	DATA UNIT MOISTURE PCF PCT	1.	HAPE OF FP.		POT VOL CHANGE (-10.056 IN.S	0	(-) 0.75 IN.SIZE SPECIF GRAVITY	2.72	

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P01550N RAT 10

YOUNGS MOD. PSIX10E6

SHORE SCHAIDT

ROD PCT FST

COMP STRNTH KPSI

ORY ₩T PCF

ROCK PROPERTIES
IGNEOUS: QUARTZ
MONZONITE COARSE GRAINED
HITH MANY SULFIDE VEINLETS.
HIGHLY FRACTURED.PRONOUNCED
ORTHOGONAL FAULTING

KEY IDENTIFICATION 13 SM

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SAMPLE SM-1

KEY							
13A TUNNEL BATA							
TUNNEL	VENI	VENTILATION		WATER INFLOW	UTILITY LINES	POWER SYSTEM	STEM
SIZE SHAPE GRADE 12FT X RECT +0.4PCF	E (FM	PRESS EXHST X	S12E HP 24IN 60	CONE P.ONE	AIR MATER PUMP 4IN 2IN BIN	PRIMARY 2400	SECONDARY 480
HAULAGE SYSTEM			SUPPORT SYSTEM				
HUCK PAIL 10 TON RAIL BOTTOM DUMP 36 IN GAGE	NEL	SUPPLY RAIL	BOLT.TYPE SIZE	ROOF PLATE	SET.SIZE.SHAPE 121N H BEAN 10ftx121Nx121N Posts # 5ft	SHOTCRETE	
MACHINE EXCAVATION							
MACHINE	נדטי	PERS.MAKE.TYPE.	CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	GES	RPM TORQUE . M.	TORQUE . MA 1/OPERATE	THEUST, MAX/OPERATE
MAKE MONEL WE	T CENTER		INTERIOR	GAGE	HEAD.CENTER HEAD	CENTER	
B-28					KFTLB XFTLB	XX XFTL TLIB	89 K K K
ANCHOR PRESS MUCK SYSTEM		POWER SYSTEM	GU1DANCE THRU	THRUST/SO FT KERF SPACING	ACING ADVANCE PEP		
*LB			* KLB				
CONVENTIONAL EXCAVATION							
MACHINE JUMBO 3 BOOM MACHINES CF79 OR D 89 FEEU LENGTH 6 FT	ROUND. NO. HOLES DEPTH S FT DIAW. 1 5/8 CUT. WEDGE SF/HOLE 2.8		EXPLUSIVES. POWDER FACTOR 3.8L TOTAL LBS 100 PRIMERS. PRIMACORD TRIM AMOGEL INTERIOR AMOGEL CUT AMOGEL LIFTERS AMOGEL	PEXPLUSIVES. POWDER FACTOR 3.6LB/CY TOTAL LBS 100 PRIMERS. PRIMACORD TRIM AMDGEL INTERIOR AMOGEL CUT AMOGEL LIFTERS AMOGEL	BLASTIR, IGNITER CORD FUSE NO 6 CAPS	LOADER LOADER	GUIDANCE TRANSIT
BASIS FOR ME NOTED BT (N) TRANSPORT SY FREE VEHICLE *POSSIBLE*TE (3) EXCESSIV	DN 15 DRY FOR SCE YSTEM CAR ES (3) BE ECHNOLOGY	SCREEN ANALYSIS W REEN ANALYSIS W ABILITY:CONVEN (LT CONV. (1) H / NOT FULLY DEV IEAR PROBABLE.	IIS AFTER WASHIN IITH NATURAL MOI ITIONAL RAIL YES IYDRAULIC PIPELI ELOPED. (1) EXC	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES. FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUHATIC *POSSIBLE.TECHNOLGSY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH. WEA	SAIL YES* PNEUMATIC PIPELINE NO WIOTH: WEAR: DAWAGE.	. A NO	CURRENT: 04/01/73

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		PCT (-) NO200	. 68	HEROID				•
POTUSON RATEO 0-35 NOTE		NO200	-	A*ANGULAR S*SUBANGULAR R*ROUNDED P.PLATY C*CUBIC I*IRREGULAR E*ELONGATED SP#SPMEROID		•		1ZE(-) IN. Angle inter Friction Degrees at Pct moist
YOUNGS B MOD. PSIX10E6 9.70		00101	5.4	AR E KELONG		TOUGHNESS	₹ 2	S.
SHORE SCHWIDTE F		NOSO NOIGO	\$. 9.	I=IRREGUL	¥	FLOW		BULK BULK DENSITY PCF AT FCT MOIST
SHORE SHORE NA	1 MEN. 0043-72	N030	9*9	C*CUBIC	4	:-	2	:
PCT ST	4ED SPEC 1.R.H021	SCREENS	15 15	-PLATY	Ĭ	PLASTICITY INDEX PCT		ARENT ESTON AT PCT NO
COMP Strnth RPSI 9	1. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.HO210043-72	TWEEN SCH	1 11.2	ROUNDED P	4	E(-) PLASTI INDEX PCT	₹ 2	HOD PSd
≻ 1⊾	0-66. 3. UE. 6. F	MFIGHT BE NO4	37.8 16.1	NGULAR R=	14	417551Z (AGE		IN. PLATE SS AT
00 11 17 17 17	AD 64661	CENT BY 1/21N•	4.8	R S=SUBAI	I ¥	REFRG LIN SMRINN LIMIT PCT	« 2	SIZE(-) ANGLE/SLIDE STEEL PLATE DEGREES AT PCT NOI
IIIC GNEISS. SED. MIY SILICIFIED.	7. INFERRED FROM D.U.DEERE AD 646610-66. Milar Rock. 5. ASSIGNED MINIMUM VALUE.	PER CENT RY WFIGHT BETWEFN ZIN. IIN. 1/2IN. NOA NOB	9 0		¥	LIGUID PLASTIC SHRINKAGE PLINITSSIZE(-) LIGUID PLASTIC SHRINKAGE PLINITS LIMIT PCT PCT PCT	4 2	ANGLE/HEPOSE ANGLE/HEPOSE 10 IN DROP DEGREES AT PCT MOIST
: GRANII HORPHOSEI HORPHOSEI HIGHLY S	RED FROM	*	0.0	EEN SIZES		PIL	2	ANGLE 10 IN DEGRE
ROCK PROPERTIES METAMORPHIC: GRANITIC HIGHLY METAMORPHOSED. MODFRATELY TO HIGHLY FRACTURED. HIGHLY SIL	NUTES: 1. AO PCI. OF FORMATION. 2. INFERRE! 4. INFERRED FROM TESTS/SIMILAR ROCK.	PCT(+16 ****		SHAPE OF FRACTIONS BETWEEN SCREEN SIZ		LIGUID LIMITS PCT	4 2	ANGLE ZEF PUSE 1 IN DROP DEGREES AY PCT MOIST
	RMATION.		0.0	CTIONS BE		AMGE IN.SIZF		
TOFNITFICATION (TMAX SAMPLE NO CL-1	I. OF FO	MOISTURE PCT	π «	OF FRA		ž		IN.SIZE F TY
	NCTES: 1. AO PCT 4. INFERA	MUCK DAIA DPY UNIT	8.7	SHAPE		POT VOI	4 Z	SPECIF GRAVITY
* 1 * ***	.	•			B-29			

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KEY											
14A TUNNEL DATA	DATA										
TUNNEL			VENTI	VENTILAT 10N				WATEP	WATEP INFLOW	UTILITY LINES	INES
S12E 13FT	SHAPE	GRADE CFW PRESS EXHST SIZE +0.25PCT 10K X 241N	F S	PRESS 6	EXHST X	S12E 241N	ş	6PM 5-10		AIR WATER PUMP 4IN 2IN	PUMP
MAULAGE SYSTEM	SYSTEM					SUPPORT	SUPPORT SYSTEM				
WUCK RAIL		PERSONNEL Rail		SUPPLY Rail		BOLT.TY NONE	BOLT. TYPE SIZE ROOF PLATE NONE	ROOF P	LATE	SET.SIZE.SHAPE	SHAPE

	CULTERS.MAKE.TYPE.DIAM.CUTTING EDGES
HACHINE EXCAVATION	HACHINE

•	HACHINE			CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	E.DIAM.CUTTIN	G EDGES	M dd	TORQUE.MAX/OPERATE	OPERATE	THRUST.MAX/OPERATE
B-30	MAKE CALWELD	MODEL HARDROCK.	200 10NS	CENTER 1 SPITH TCB TRICONE. 24IN	INTERIOR 12 SMITH TCB GIMHR ROLLER	GAGE 6 SMITH TCB GTSHB ROLLER	HEAD+CENTER 12 - 26	HEAD KFTLB 347 KFTLB	CENTER KFTL8 KFTL8	KLB 133 KLB 130
	ANCHOR PRESS	RESS HUCK BUCKE FACE, CONVE	HUCK SYSTEM BUCKET FROM FACE, CONVEYOR TO REAR 241N	POWER SYSTEM ELECTRO- HYDRAULIC 825 HP	GUIDANCE LASER	THRUSI/SQ FT KERF SPACING AGVANCE PER FEET HOUR.FT. KLB 5.09 0.09 Z.0	PACING ACVAN T HOU	CE PER Rof1. 2.0		

CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER, FACTOR TOTAL LGS PRIMERS,	INTERIOR CUT CIFTERS
ROUND. NO. HOLES DEPTH DIAM.	•
MACHINE JUMBO MACHINES	FEED LENGTH

GUIDANCE

MUCK ING

EL AST ING

		YES	
		PIPELINE	
BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS MOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOTSTURE.	TRANSPORT SYSTEM CAPABILITY: CONVENTIONAL RAIL YES SIDE RAIL YES*	FREE VEHICLES YES BELT CONV. YES HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES	*POSSIBLE T. CHNOLOGY NOT FULLY DEVELOPED.
BASIS + 28 MDN IS D	TRANSPORT SYSTEM C	FREE VEHICLES YES	ODDISTRIF F.T. CHNOLD

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		PCT (2.3	I Q V			ž F	
PO1550K RATIO A 134 NOTE 2		NO200		NGATED SP	•		SIZE(-)2.0 I ANGLE INTER FRICTION DEGRE, 2 AT 0.4 PCT MOIST	7
YOUNGS MOD. PSIX10E6 11.20 NOTE		,	•	AR E=ELO	TOUGHNES	90.0		•
	•	NO50 NO100 NO200	0	R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED	X E	•	BULK DENSITY PCF AT	117.8
SHORE SCHNIDT	3. UNPOLISMED SP. CIMEN. b. FROM CSM A.R.HO. 10043-72.	NO30	6.0	C=CUB1C	FLOW	5.50		
200 EST 80	ISHED SP!	CREENS	1.6 1.2	P=PLATY	561N.		APPARENT COMESION PSF AT 0.4 PCT HOIST	175
COMP STRNIH KPSI 26	3. UNPOL.1 FROM CSF	BETWEEN SCREENS NOB NOIG	2.8 1.	REGUNDED	ZE(=) 0.0 PLAST INCEX PCT	0.33	IN APP	
			Ž		Is••		INE ATE AT MOIST	
DPY HT PCF	FROM D.U.DEERE AD 646610-66. S. ASSIGNED MINIMUM VALUE.	PER CENT BY WEIGHT IN. 11N. 1/21N. NO4	8.7	S#SUBANGULAR AI	**************************************	17.80	SIZE(-)2.0 ANGLE/SLIDE STEL PLATE DEGREES AT 1.5 PCT MOIS	62
2 98	AD INTHU	CEN]	10.6	A AR	ERBEA S L P		SIZE (
METAMORPHIC: INTERLATERED METAMORPHIC: INTERLATERED AND TACTITE, MODERATELY TO STRONGLY ALTERED METASEDIMENTS WITH REPLACEMENT PYRITE, CHALCOPYRITE AND MAGNETITE AND A HIGH PERCENTASE OF SILICATES VERY FINE TO MEDIUM	J.U.DEERE SIGNED MI	ZIN. 1IN.	10.2	A=ANGULAR AI AI	ASTIC HIT	7.92	ERIAL POSE OP AT MOIST	
IES INTERLA MODERATE ERED META MENT PYR AND MAGE HEDIUM	ED FROM (6IN. GIN. Z	17.4 9.1	N SIZES	PLA LIM PCT	11	ANGLE/RE 10 12 OR DEGREES 1.5 PCT	56
METAMORPHIC: INTERLARANSITION BETWEEN AND TACTITE, MODERA SIRONGLY ALLERED ME WITH REPLACEMENT PY CHALCOPYRITE AND MA HIGH PERCENTASE OVERY FINE TO MEDIUM GRAINED.	AR ROCK		-	EN SCREE	IOUID IMITS	18.25	POSE P A A A A A A A A A A A A A A A A A A A	
ROCK PRO METAMORY TRANSITY AND TACT STRONGLY WITH REP CHALCOPY A HIGH P VERY FIN	TION. 2	PCT (+)6 IN.SIZE	34.1	NS BETWE		-	SLE / RE SRE S SRE ES PCT	30
CAT 10N	SE FORMATES	MOISTURE PCT	0 • 11	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES	POT VOL CHANGE (-)0.056 IN.SI7E			
LK LK SAMPLE NO LK-3	NOTES: 1. 90 PCT. OF FORMATION. 2. INFERRED 4. INFERRED FROM TESTS/SIMILAR ROCK.	DATA	105 0	SHAPE OF	POT VOL (-)0.056	0	(-)0.75 IN.SIZE SPECIF GRAVITY	3.21
XE 15	1.:	MUCK DRY		B-31			-	

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VENTILATION	WATER INFLOW UTIL.	POWER SYSTEM PRIMARY SEC	STEM
CFR PRESS EARS! SIZE 52K HEAD SURF 48IN	150 NONE SIN SIN	NO91	>0 2 2
odans	SUPPORT SYSTEM		
SUPPLY BOLT. DIESEL 3/4IN TRUCK AT 4F	BOLT.TYPE SIZE ROOF PLATE SET.SIZE.SMAPE 3/4IN X 6FT 13.5IN X 9FT AT 4FT	SHOTCRETE	•
CUTTERS.WAKE.TYPE.DIAM.CUTTING EDGES	A. O. A.	TOHOUE.MAX/OPERATE	THRUST . MAX/OPERATE
CENTER INTERIOR	A GAGE MEAD.CENTER HEAD	CENTER	
	KF1LB B.T.T.	KFTL8	77 68
POWER SYSTEM GUIDANCE THRUST/SQ FT KERF SPACING ADVANCE PER KLB			÷

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15A TUNNEL DATA

CONVENTIONAL EXCAVATION

BLASTING ELECTRICAL D+15 REGULAR DELAYS	
EXPLOSIVES. POWDER FACTOR 4.2LB/CY FOTAL LBS 265 PRINERS: ISLB 1.5IN X BIN: 60-75PCT TRIM ISLB 7/BIN X 16IN: 30PCT INTERIOR ANFO OUT 24: B 1.5IN X 16IN: 45PCT	LIFTERS ANFO
ROLWD. NO. HOLES 42 DEPTH 6FT OTAM. 1-3/4IN CUT. 6 HOLE BURN I 1-4IN CNTR HOLE	SF/HOLE 5.3
MACHINE JUMBO 3 BOOM MACHINES 3-PR123 DRIFTERS FEED LENGTH 12FT	

MUCK ING SCOOPTRAM

BASIS FOR HDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES*
FREF VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO
*POSSIBLE.TECHMOLOGY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH: WEAR. DAMAGE.
(3) EXCESSIVE TIRE WEAR PROBABLE.

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	PCT (-)	SP=SPHER010			**O IN*
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	NO30 NO50 NO100 NO200	A*ANGULAR S&SUBANGULAR R=ROUN.ZD P*PLATY C*CUBIC I*IRREGULAR E*ELONGATED SF	• • • • • • • • • • • • • • • • • • •	•	SIZE(-) 2.0 ANGLE INTER FRICTION DEGREES AT 0.2 PCT NOIS
MODE MODE MODE MOTE NOTE	NO100	KAR E=E	AI TOUGHNESS INDEX INDEX	0.19	HOIST (
		I=IRREGU		o.	BULK DENSITY PCF AT 0.0 PCT NO:
SHORE SCHNIOT NA 33	Q	C=CUBIC	AI FLOW INDE,	5.40	BUL DEN PCF MOIST 0.0
FST SFECT SF	EENS 1016 1 2	'=PLATY (AI AI AI A PLASTICITY INDEX PCT		APPARENT COHESION PSF AT 0.2 PCY NO
E 00.15	BETWEEN SCREENS NOS NOIG	9 05. NU0	AI (-) 0.05 PLASTI INDEX PCT	1.05	
SINGLE SINGLE SPECIMEN L/R = 1.	16H7 BETV NO4 N	LAR R=RI	11 AI AI AI AI AI PLASTIC SHRINKAGE PLIMIT LIMIT PCT PCT		IN ATE ATE HOIST
TE STRONGL' DRY NETA- WI NETA- WI TE AND GH PER- ES. FINE TO H D.U.DEERE AD 646610-66.	ENT BY WEIGHT 1/2 TN. NO4 5 7.3	≖ SUBANGU	AI RG LIMIT SHRINKAG LIMIT	16.43	E(-) 2.0 1 ANGLE/SLIDE STEEL PLATE DEGREES AT 2.0 PCT MOIS
T TO TO ERE AD (PER CENT IIN. 1/2	GULAR S	AI ATTERBE		5171
TE STRONGL META TE AND GA PER ES, FINE T ES, FUE T	ASSIGNED MINI ZIN. 11N. 3.7 13.9 9.		A AI AI PLASTIC LIMIT PCT	17.95	MATERIAL ANGLE/REPOSE 10 IN DROP DEGREES #1
FR CATE		EEN SIZE	4		ANG 10 0EG
METAMORPHIC: TACTITE STRO ALTERED CALCAREOUS META- SEDIMENTS, WITH REPLACEMED PYRITE, CHALCOPYRITE AND HAGNETITE AND A HIGH PER- CENTAGE OF SILICATES, FIN VERY FINE GRAINED.	LAR 200	EEN SCRI	AI AI LIOUIO L'EIMITS L'E	19.00	
LX-4 LX-4 MAGNETITE ALTERED CALCARE SAMPLE NO PYRITE: CHALCOP LX-4 MAGNETITE AND A CENTAGE OF SINFERRED NOTES: 1.80 PCT. OF FORMATION. 2. INFERRED	515/51MILA PCT (+)6 IN-512E 26-3	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES	i e		ANGLE/REPOSE 1 IN DROP DEGREES AT 2.0 PCT HOIS
7 G	FROM TES MOISTURE PCT	FRACTI	POT VOL CHANGE		
SAMPLE NO LX-4 ES-6 ES-6 ES-6 ES-6 ES-6 ES-6 ES-6 ES-6	INFERRED ** DATA ** CATA **	SHAPE OF	POT VGL.	6	(~) 0.751N.SIZE SPECIF GRAVITY
1 DE 1	* * * * * * * * * * * * * * * * * * *				•

KEY 10

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				_				THRUST . HAX/OPERATE	1	* * * * * * * * * * * * * * * * * * *				NCE.
			.TEM	SECONDARY 220V				THRUST.H	;	¥¥				GUIDANCE
			POWER SYSTEM	PRIMABY 4160V		SHOTCRETE		ATE	CENTER	8 8				MUCK ING SCOOPTRAN
1				_		SHOT		IAX/OPER		AFTL BILL B				
			s	PUMP		PE SETS		TORQUE.MAX/OPERATE	HEAD	KFTLB KFTLB	E PER			BLASTING ELECTRICAL 0-15 REGULAR
			UTILITY LINES	BATER		SET+SIZE+SMAPE 6in wf Stell Sets at sft			HEAD.CENTER		ADVANCE PER			<u> </u>
į,			UTIL	6 1 8 1 8 1 8 1 8 1 8 1 8 1 8 1 8 1 8 1		S TA		A A	HEAD		KERF SPACING FEET			
			WATER INFLOW			ROOF PLATE								4.6LB/CY
			WATE	CPH	*			ENGES	GAGE		THRUST/SQ FT	æ.		EXPLOSIVES. POWDER FACTOR 4
				150 150	SUPPORT SYSTEM	BOLT.TYPE SIZE MONE		M.CUTTING EDGES	α			K &		XPLOSIV OWDER F
				S12E	SUPPORT	BOLT.T		DIAM.C	INTERIOR		GUTDANCE			WAF
!			ATION	PRESS EXHST HEAD SURF		SUPPLY DIESEL TRUCK		CUTTERS.MAKE.TYPE.DIA			POWER SYSTEM			Ž,
			VENTILATION	15 M				CUTTER	CENTER		, 0			ROUND.
				GRADE •2.0PCT		PERSONNEL DIESEL TRUCK			5		MUCK SYSTEM		ATION	
				SHAPE ARCHED BACK	SYSTEM		KCAVATION		MODEL				VAL EXCAV	8004
	KEY	16A TUNNEL DATA	TUNNEL	S12E S15FT X A	HAULAGE SY	MUCK WAGNER ST-8 *(CODPTRAM R: [L* SKIP	MACHINE EXCAVATION	MACHINE	MAKE	B-34	ANCHOR PRESS	KLB	CONVENTIONAL EXCAVATION	MACHINE JUNBO 3 BOOM

DEPTH 6 FT DIAM 1-374IN CUT. 6 HOLE BURN 1-4IN CENTER HOLE SF/HOLE 4.7 MACHINE JUMBO 3 BOOM MACHINES GARDNER DENVER (3-PR123 DRIFTERS (

TOTAL LBS 205
PRINCES, 15LB 1.5IN X BIN. 60-75PCT
TRIN 15LB 7/BIN X 16IN. 30PCT
INTERIOR ANFO
CUT 25LB 1.5IN X 16IN. 45PCT
LIFTERS ANFO

DELAYS

BASIS FOR MDW IS DRY SCREEN AMALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN AMALYSIS WITH NATURAL MOISTURE.
NOTED BY (N) FOR SCREEN AMALYSIS WITH NATURAL MOISTURE.
FREE YEMICLES (3) BELT TYLCONVENTIONAL RAIL YES SIDE RAIL YES.
*POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH: WEAR. DAMAGE.
(3) EXCESSIVE TIRE WEAR PROBABLE.

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M8-1

		PCT (-)	1.5.3	SPHERO I D				ž r	
POISSON RATIO NOTE NOTE		00200		S#SUBANGULAR R=ROUNDED P#PLATY C#CUBIC I*IRREGULAR E#ELOHGATED \$P#SPHEROID		•		SIZE(-)2.0 1 ANGLE INTER FRICTION DEGREES AT 6.9 PCT MOIST	
YOUNGS MOD. PSIXIGE ROTE A		0010	1:1	.AR E=EL		TOUGHNESS	9.0	v. .	
		NO30 NOSO NOTO	1.3	* I RREGU	¥			1177 AT H0157	
SHORE SCHNIDT NA 20 NOTE 3	EN. 43-72.	Ž	1.6	CUBIC I	41	FLOW	;	DENE POF POF	
	SPECIM	NS	3.3	LATY C=	4	IN.		SSION AT PCT MOIST	
T POCT S	. 3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.H0210043-72.	BETWEEN SCREENS	4.5	40ED P=P	14	PLASTICITY INDEX PCT	2.1	INS APPARENT COMESION PSF AT ST 6.9 PCT N	
COMP STRNTH KPSI 7	3. UNF 6. FROM	T BETWEE!	10.3	R R=ROUN	¥	.SIZE (=)	Ň	IN IDE ATE AT AT HOJST	
DRY WI FCF 207		PER CENT BY WEIGHT ZIN. 11N. 1/ZIN. NO4	20.1	BANGULA	¥	PLASTIC SHRINKAGE FLIMIT PLIMIT IN THE PCT	13.9	SIZE(-)2.0 ANGLE/SLIDE STEEL PLATE DEGREES AT 6.2 PCT NOS	
•	E AD 646 INIMUM V	PER CENT BY	***	LAR S#SL	¥1	TERBERG LI SHRIN LIMIT PCT			
	H D.U.DEFRE AD 646610-66 ASSIGNED MINIMUM VALUE.	ZIN. 11	P. 80	A=ANGULAR	7	STIC	15.1	••MATERIAL LE-REPOSE IN DROP REES AT PCT MOIST	
AND HAD NORMAL NORMAL TIGHLY F	FROM D	31W. 2	*:	u sizes	¥	PLAST LIMIT PCT	51	ANGLE/RE 10 IN DR DEGREES 6.2 PCT	
MECANORPHIC: LYTER LAYERED BANDS HEMATITE AND MARTITE HIGHLY JOINTED NORMALLY FLAT LYING: OFTEN HIGHLY FOLDED: NATURAL IRON OVER 60 PCT MOISTURE 9 PCT: SILICA 5 PCT	2. INFERED FROM D.U.DEFRE HILAR ROCK. 5. ASSIGNED MIN	**************************************	4.4	N SCREEN	AI	LIGUID LIMITS PCT	.	P05E PP AT M01ST	
METAMORPH BANDS HEN HIGHLY JO LYING OF NATURAL I	NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRE! 4. INFERRED FROM TESTS/SIMILAR ROCK.	PCT(+)6 IN+SIZE	7.2	SHAPE OF FRACTIONS BETWEEN SCREEN SIZ	A 1	נובי.	17.8	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	
2	FORMATIC DM TESTS	STURE		RACT IONS	•	IN.SIZE		3 0	
MATMER B SAMPLE NO MB-1	CT. OF ! RRED FR		7.2	96 el		POT VOL CHANGE		(-)0.75 IM.SIZE SPECIF GRAVITY	
	NOTES: 1. 80 P	MUCK DATA DRY UNIT #T PCF	128	SH		P07	•	(+) 0 SPE GRA	
X	€ 1	•			B-35				

13161	Secondary 440v				THRUST . MAX/OPERATE	KLB 300 KLB 300			GUIDANCE	CURRENT: 04/01/73
POWER SYSTEM	A RESIDE		SHOICAETE		TORQUE+MAX/OPERATE	CENTER 1200 KFTLB KFTLR			MUCH ING	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
UTILITY LINES	AIR MATER PUMP ZIN BIN		SET.SIZE.SHAPE OFT GIN DIA. X AIN WF AT ASIN		RPW TORQUE.W	HEAD.CENTE? HEAD 8 KFTLB 12 KFTLB	KERF SPACING ADVANCE PER FEET HOUR.FT.		BLASTING	SA AAIL YES# PNEUMATIC PIPELINE NO BIOTH+ WEAR+ DAMAGE+
WATER INFLOW	GPM		ROOF PLATE		DGES	GAGE 20 CARS: RIPPERS	TWRUST/SQ FT KERF FE		C100	NG UNLESS 1STURE. S SIDE RAIL YESP INE NO PNEUMATI CESSIVE WIDTH: W
	SIZE		BOLT.TYPE 512E		.DIAM.CUTTING EDGES	INTERIOR 258 CARBOLOY DRAG BITS	GUIDANCE SURVEY		EXPLOSIVES. POWDER FACTOR TOTAL LBS FRIMERS. TRIM INTERIOR CUT	SIS AFTER WASHI WITH NATURAL MO INTONAL RAIL YE HYDRAU IC PIPEL VELOPED. (1) EX
VENTILATION	CFM PRESS EXHST		SUPPLY RAIL HOIST		CUTTERS.MAKE.TYPE.	CENTER	POWER SYSTEM REMOTE HYDRAUL. PUMPS, 2-90GPM. 2500 PSI. 2-125 HP MOTORS		ROUND. NO. HOLES DEPTH DIAM. CUT.	BASIS FOR MOW IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YESFEE VEHICLES VES BELT CONV. (1) MYDRAW IC PIPELINE NO PNEUMATIC. POSSIBLE.TECHNOLOGY NOT FULLY DEVELOMED. (1) EXCESSIVE WIDTH. W
-	GRADE 0.0		PERSONNEL Rail Hoist	NOI		MODEL WT OCCILLATOR 69 TONS	MUCK SYSTEM CONVEYOR TO REAR OF MACHINE	EXCAVATION	ROUND. NO. HO DEPTH CUT.	IIS FOR MOM IS NSPORT SYSTEM E VEHICLES YE ISSIBLE TECHNO
	SIZE SHAPE 9FT ROUND 11.5IN	HAULAGE SYSTEM	MUCK 421N SCRAPER RAIL	MACHINE EXCAVATION	HACHINE	HAKE HODE CALVELD OCCI		CONVENTIONAL EX	MACHINE JUMBO MACHINES FEED LENGTH	98 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

KEY 17A TUNNEL DATA

		PCT (-) N0200	5.7		SP#SPHEROID				2	
POISSON RATIO 0.15				FORE DRYING	E=ELONGATED SPA		8 • • • • • • • • •		SIZE(-)2.0 10 ANGLE INTER FRICTION DEGREES AT 11.56PCT MOIST	16
YOUNGS MOD. PSIXI0E6		NO 100		SCREENED BEFORE	LAR E=EL(TOUGHNESS	0.11		
NESS SCHMIDT 16	•	NOSO	1.7	LINE. SCR	I=IRREGULAR	¥	FLOW	_	BULK BULK DENSITY PCF AT 11.56PCT HOIST	119.6
SHORE SCHMIDT NA 16	CIMEN.	SCREENS	1.3	LOWER	C*CUBIC	4	FLOW	5.1	BUL DEN JOIST 11:5	•
POD PCT PCT POT	ISHED SPE M A.R.HOZ	SCREENS	5.5 5.6 7.0 3.1	TM C117).	DEPLATY	4	PLASTICITY INDEX PCT		APPARENT CC-ESION PSF AT 11.56PCT -4	120
COMP STRNTH KPSI 6	3. UNPOLISHED SPECIMEN. 6. FROH CSM A.R.HO210043-72		8.0 S	WASHING (ASTM	R=ROUNDED	A1 A1	ST7E:-; U.G PLAST INDEX PCT	9.0		
DRY WT PCF	•	PER CENT BY WEIGHT BETWEEN IIN. 1/2IN. NO. NO.	16.8	AFTER	S*SUBANGULAR	V V	ATTERBERG LIMITSS Smrinkage Limit PCI	19.0	SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT II.SGPCT MOIST	30.17
٥	DEERE AD ED MINIMU	PER CEN	6.8 10.4 7.0 12.8	(ASTH C136) •	A=ANGULAR S	AI-P AI	. ATTERBE		IAL SE IST	
ROCK PROPERTIES METAMORPHIC: INTERLAYERED HEMATITE AND MARTITE HIGHLY JOINTED, NORMALLY FLAT LYING, OFTEN HIGHLY FOLDED, NATURAL IRON 60 PCT, SILICA 5 PCT	FROM D.U.DEERE AD 646610-6 5. ASSIGNED MINIMUM VALUF.	21N.	2.7	CREENED	SIZES As	AI-P	PLASTIC LIMIT PCT	20.86	NGLE/RE O IN DR EGPEES SSPCT	30.5
ROCK PROPERTIES IN METAMORPHIC: IN HEMATITE AND MAH HIGHLY JOINTED. FLAT LYING, OFT FOLDED, NATURAL 60 PCT. SILICA		6 IN SHA	17.3	UPPER LINE. DRY S		AI-P	LIQUID LIMITS PCT	20		
ROCK PROPERTAMORE HEMATITE HIGHLY FLAT LY FOLDED.	ION. P. TS/SIMTLA	PCT (+)6 IN.S12E	16.1 15.9	UOPER LI	IS BETYEEN	AI-P	•	21,50	ANGLE/REPOSE 1 IN DROP DEGREES AT 11.56PCT MOIST	35.5
1CAT10N NO	NOTES: 1. 80 PCT. OF FORMATION. ?. INFERRED 4. INFERRED FROM TESTS/SIMILAR ROCK.	MOISTURE PCT	14.5	NALYSIS:	OF FRACTIONS BETWEEN SCREEN		POT VOL CHANGE (-)0.056 IN.SIZE		IN.SIZE +.	
IDENTIFICATION MB SAMPLE NO MB=3	NOTES: 1. 80 PCT. 4. INFERRED	K DATA Y UNIT PCF	140	SCREEN ANALYSISE	SHAPE OF		POT VOL		(=)0.75 I SPECIF GRAVITY	4.31
× 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	N - 4	M Q Q M F				R 27				

CURRENT:

POWER SYSTEM	PUMP PRIMARY SECONDARY 2300 440	PE SHOTCRETE POSTS	TORQUE•MAX/OPERATE THRUST•MAX/OPERATE	HEAD CENTER KLB 2-10 KFILB KFTLB KLB 2-10 KFILB KFTLB	# # # # # # # # # # # # # # # # # # #	BLASTING MUCKING GUIDANCE
UTILITY LINES	ALP WATER PU	SET.SIZE.SHAPE BIN-58LB WF SETS 7FT CAP. 8FT POS WOOD LAGGING PIPE SPILING	M d d	HEAD CENTER 600	KERF SPACING ADVANCE PER FEET HOUR.FT. NA	BL A1
WATER INFLOW	GPM	H ROOF PLATE	EDGES	GAGE	THRUST/SQ FT KERF	PAFE S C T O R S C T O R
	1 SIZE HP 81N 15	SUPPORT SYSTEM BOLT+TYPE SIZE	E.DIAM.CUTIING	INTERIOR NO. 43KH TCB HEADS	GUIDANCE TE TRANSIT	EXPLOSIVES. POWDEP FACTOR TOTAL LES PRIMERS. TRIM INTERIOR
VENTILATION	FFM PRESS EXHST	SUPPLY RAIL	CUTTERS.MAKZ.TYPE.DIAM.CUT11NG EDGES	CENTER 68 KENNAMETAL.N ON TWIN RIPPER	POWER SYSTEM	ROUND. NO. HOLES OFFTH CUTAM.
	GRADE 0	PERSONNEL Rail	ž	THE STATE OF THE S	AUCK SYSTEM Gathering Arms+Flight Conveyors	
TUNNEL	SIZE SMAPE 10FTX RECT 9FT 6 IN	MAULAGE SYSTEM MUCK 48IN SCRAPER 160 CF CARS 20-30T MOTORS 30 IN GAGE 60 LB RAIL	MACHINE EXCAVATION	HAKE HODEL ALPINE 5-6A	ANCHOR PRESS KLB	CONVENTIONAL EXCAVATION MACHINE JUMBO MACHINES

KEY 18A TUNNEL DATA

POTSSON R.1.10	0.13
YOUNGS	
SHORE SCH. "01	45
SHORE	2
800 PCT	EST 75
COMP	I &
	10 0 0 E
RUCK PROPERTIES METAMORPHIC: ARGILLIACEOUS QUAPTZITE, MEDIUM TO THIN	REDNED.MODERATELY TO HIGHLY FOLNED. MODERATE FRACIURING
KEY IDENTIFICATION	SAMPLE NO

45 6. FROM CSM A.R.H0210043-72. **₹** 13 2 NOTES: 1. 80 PCI. OF FORMATION. 7. INFERRED FROM D.U.DEERE AD 646610-66. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. (168 FOLDED - MODERATE FRACTURING SAMPLE ST-1

PCT (-) NO200	2.0
2IN. 11N. 1/2IN. NO4 NOS NO16 ND30 NO50 NO100 NO200 N	.3
1050 NO	5.4 4.5 4.4 1.3 1.1 0.7 0.5 0.4 (
N030	0.5
EENS	0.1
EEN SCR 08 N	1.1
HT BETW 4 N	1.3
BY WEIGIN. NO	4.
R CENT N. 1/2	6.5
IN. 11	5.4
JIN. 2	1.9
6in. 3in.	8.1
PCT (+)6 IA-S17E	71.2
MO;STURE PCT	1.0
MUCK DATA DRY UNIT WI PCF	76

SIZES A=ANGULAR S=SUBANGULAR R=ROUNDID P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPHERO		TOUGHNESS	0.50	SIZE(-)2.0 IN. ANGLE INTER FPICTION OEGREES AT 0.26PCT MOIST	32.7
I=IPREGULAR	¥		0	BULK BULK DENSITY PCF AT 0.26PCT MOIST	16
/ C=CUBIC	A1	FLOS	5.10	1210	
ED PRPLATI	AI AI	0.0561N ASTICITY DEX		APPARENT COMESION PSF AT 0.26PC1 MOIST	740
R R=ROUND	, IA	SIZE(-1 0. PLA: INDE	2,53	1N	
= SUBANGULA	AIE	PLASTIC SHRINKAGE PLASTICITY PLASTIC PLASTICITY PLASTIC PLASTICITY PLASTICITY PCT PCT	10.91	E(+)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 0.26PCT MOIST	31.17
VGULAR S	E PE	.ATTERBE		IAL SIZE Se IST	
SIZES A=A)	APE APE		15.57	ANGLE/REPOSE ANGLE/S:0 ANGLE/REPOSE ANGLE/S: 10 IN DROP STEEL P: 10 GREES AT DEGREES 0.26PCT MOIST 0.26PCT	33.60
SH.PE OF FRACTIONS BETWEEN SCPEEN	APÉ	LIGUID LIMITS PCT	18.10		
FIONS BETW	4 0£			ANGLE/REPOSE 1 IN DROP DEGREES AT	37,15
OF FRAC		POT VOL CHANGE (-)0.056 IN.SIZE		(-) 0.75 IN.SIZE SPECIF GRAVITY	
SH .PE		70 TOG	•	(-)0.75 SPECIF GRAVII	2.689

ST-1

04/01/73

CURRENT: 04/01/73

DATA 19A TUNNEL KEY

STREET STREET,
1

SECONDARY 480 POWER SYSTEM PRIMARY 2300 SHOTCRETE AIR WATER PUMP 4 IN 2 IN SET.SIZE.SHAPE UTILITY LINES ROOF PLATE 9FTX13IN MATS MATER INFLOW SPH BOLT.TYPE SIZE 6FTX.75IN 4/ MAT SUPPORT SYSTEM Ŧ 0 S12E PRESS EXHST SUPPLY RAIL VENTILATION HU ~ PERSONNEL Rail SHAPE GRADE ARCH BACK +0.5PCT 60 CF SIDE DUMP 40 LB RAIL 24 IN GAGE 6 T MOTOR HAULAGE SYSTEM 10.7FT LUNNEL S12E 9FTX ¥0C¥

MACHINE EXCAVATION

THRUST . MAX/OPERATE CENTER TORQUE . MAX/OPERATE KFTLB KFTLB KFTLB KFTLB HEAD.CENTER HEAD RPM CUTTERS+MAKE+" I PE+DIAM+CI 1 TING EDGES INTERIOR CENTER -MODEL MACHINE MAKE B - 40

KERF SPACING ADVANCE PER FEET HOUR, FT.

THRUST/SO FT

GUIDANCE

POWER SYSTEM

ANCHOR PRESS MUCK SYSTEM

KLB

X LB

CONVENTIONAL EXCAVATION

EXPLOSIVES.
POWDER FACTOR 5.5LB/CY
TOTAL LBS 125
PRIMERS. 25LBS 60WR 1X16 IN
TRIM NILITE
INTERIOR NILITE
CUT NILITE
LIFTERS NILITE ROUND. NO. HOLES 44 DEPTH 7 FT DIAK. 1 5/8 IN CUT. BURNZ-4 IN SF/HOLE 2.2 2-583F 1-099 FEED LENGTH 8FT **800m** MACHINE JUMBO 3 6 MACHINES

MUCKING ATLAS-COPCO LMS6 BLASTING ELECTRICAL 0-14 REGULAR DELAYS

GUIDANCE TRANSIT

BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN AMALYSIS WITH NATURAL MOISTURE,
TRANSPORT SYSTEM CAPABILITY:CONVENITONAL RAIL YES SIDE RAIL YES+
FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO
+POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (1) EXCESSIVE WIDTH. WEAR. DAMAGE.
(3) EXCESSIVE TIPE WEAR PROBABLE.

ST-1

		PCT (-) NO200	o. o	**SPHEROID			
POISSON RATTO 0.18		NO200		NGATED SA		• • • • • •	
YOUNGS MOD. PSIXIOE6		900	9.	LAR ERELO		TOUGHNESS	0.34
	•	NO50	•	1=IRREGU	4	PLASTICITY FLOW INDEX	06
SHORE SCHAIDT	6. FROM CSM A.R.HG210043-72	NO 30	•••	r c=cusic	¥		06**
PCT FST 50	ISHED SPI H A.R.HO	SCREENS.	1.9 1.0	D PEPLATI	14 14	.056IN Sticity Ex	
COMP STRNTH KPSI 13	3. UJPOL.	BETWEEN	1.9	R=ROUNDE	A A	SIZE(-) 0.0 PLAST INDEX PCT	1.67
DRV W1 PCF	646610-66. M VALUE. 6.	**************************************	6	A*ANGULAR S*SUBANGULAR R*ROUNDED P#PLATY C*CUBIC [*[RREGULAR E*ELONGATED \$P*SPHEROID	*	PLASTIC LIMITSSIZE(-) PLASTIC SHRINKAGE PI LIMIT LIMIT PCT	11.76
FRACTURED ILLED	NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. (ZIP. IIN. 1/ZIN.	14.1 10.2	A=ANGULAR S	AI AI	PLASTIC LIMIT PCT	14.83
ES QUARIZITE LDED HIGHLY FR HINOR FILL PING 75-90	D FROM D. S. ASS.	31N. 21	2 8.5	N SIZES	I V	•	14.
ROCK PROPERTIES HETAMORPHIC: QUARTZITE HODERATLEY FOLDED HODERATELY TO HIGHLY FRACTURED /JOINTED #ITH HINOR FILLED VEINLETS: DIPPING 75-90 DEGREES	2. INFERRE ILAR ROCK.	36 3ER.	9	SHAPE OF FRACTIONS BETWEEN SCREEN SI	¥	LIOUID LIMITS PCT	16.50
C C C C C C C C C C C C C C C C C C C	IESTS/SIN	RE PCT(+16	44.7	TONS BET	¥	; ; ; ;	
IDENTIFICAT' 7N CR SAMPLE NO GR-1	OF FORE	MGISTURE PCT	1.7	OF FRACT		POT VOL CMANGE (-)0.056 IN.SIZE	
KEY IDENTIFIC ZO CR SAMPLE NO CR~1	NOTES: 1. 80 PCT 4. INFERR	MUCK DATA DBY UNIT	4	SHAPE		POT VOL C	0

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90

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31.75

4.3

37.6

2.714

APPARENT BULK
COMESION DENSITY
PSF AT PCF AT
6.28 PCT MOIST 8.28 PC? MOIST

ANGLE/REPOSE ANGLE/SLIDE
10 IN DROP STEEL PLATE
DEGREES AT DEGREES AT
0.28 FCT MOIST 0.28 PCT MOIST

ANGLE/REPOSE
1 IN DROP
DEGREES AT
0.28 PCT MOIST

SPECIF SPECIF GRAVITY

04/01/13

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Annual series

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1	SECONDARY 480				THRUST . MAX/OPERATE		7 7 2 0 2 0				Guidance Laser	CURRENT: 04/01/73
POWER SYSTEM	PAIMARY SE 2500		SHOTCRETE			CENTER	77 77 77 8 8				ELIKCO ELIKCO CHISS CHIS CHI	E NOW
UTILITY LINES	AIR WATER PUMP 4 IN 2 IN 2 IN		SET.SIZE.SHAPE		TORQUE . MAX/OPERATE	HEAD.CENIER HEAD	KFTLB KFTLB	ADVANCE PER HOUR+FT.			BLASTING ELECTRICAL DUPONT ACUDET 0-14	INE NO
	AIR A IN				Ada	HEAD		KERF SPACING			3/CY	AAL YES* PNEUMATIC PIPELINE NO WIDTH: WEAR* DAMAGE.
WATER INFLOW	M I NOB	.	E ROOF PLATE 9 FTX 13 IN	•	EDGES	GAGE		THRUST/SQ FT			EXPLOSIVES, POWDER FACTOR 9.5 LB/CY TOTAL LBS 265 PRIMERS, 12LB TROJAN 60 WR. TATEM NILITE CUT NILITE LIFTERS NILITE	AFTER WASHING UNLESS NATURAL WOISTURE. NAL RAIL YES SIDE RAIL YES* AULIC PIPELINE NO PNEUMATI PED. (1) EXCESSIVE WIDTH. W
	SIZE HP 24 IN 30	SUPPORT SYSTEM	BOLT.TYPE SIZE S FT X 5/8 IN		IAM, CUTTING EDGES	INTERIOR		GUIDANCE TH	KLB		EXPLOSIVES, POWDER FACTOR 9 TOTAL LBS 265 PRIMERS, 15LB T TRIM MILITE INTERIOR MILITE CUT NILITE	IS AFTER WASH IIH NATURAL M IONAL RAIL Y IDRAULIC PIPE ILOPED. (1) E
VENTILATION	CFM PRESS EXHST 2	M	SUPPLY B		CUTTERS.MAKE.TYPE.DIAM	CENTEP IN		POWER SYSTEM			ROUND. NO. MOLES 48 DEPTH B FT DIAM. 1 INX5/8 IN CUT. V	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WAS NOTED BY (N) FOR SCREEN ANALYSIS WITH MATURAL TRANSPORT SYSTEM CAPABILITYICONVENTIONAL RAIL FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIP +POSSIBLE.TECHNÖLOGY MOT FULLY DEVELOPED. (1) (3) EXCESSIVE TIRE WEAR PROBABLE.
>	GRADE CI		PERSONNEL LHD	z		υ ##		MUCK SYSTEM		VATION	ROUND. NO. HOLL DEPTH 8 DIAM. 1 CUT. V	FOR MDN 1S 987 (N) FOR SPORT SYSTEM VEHICLES (3) 118LE-TECHNON
	SHAPE ROUNDED CORNERS	E SYSTEM		HACHINE EXCAVATION	i.	MODEL		ANCHOR PRESS MU		CONVENTIONAL EXCAVATION	MACHINE MACHINES D-93 FEED LENGTH BFT	BASIS NOTEC TRANS FREE FPEE 131 E
TUNNEL	S12E 10 FT 10 FT	MAULAGE	MUCK EIMCO 9128 L.H.D. SKIP	MACHINE	# CH	MAKE	B-42	ANCHO	кг8	CONVEN	HACHINE JUMBO 2 HACHINES FEED LENG	

20A TUNNEL DATA

KEY

POISSON	0.20
YOUNGS MOD. PSIXIOE6	8.62
HARDNESS	7
SHORE	¥ Z
800 PCT EST	70
COMP Strnth KPSI	91
DRY PCF	187
ROCK PROPERTIES METAMORPHIC. PHYLLITE WITH VEINDUARTZ. CM.ORITE SCHIST HIGHLY METAMORPHOSED AND	
KEY IDENTIFICATION 21 HOMESTAKE SAMPLE NO	1 - 0 *

NOTES: 1. 83 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSH A.R.HO210043-72.

PCT (-)	3.0
61N. 31N. 21N. 11N. 1/21N. NO4 NO8 NO16 NO30 NO50 KD100 NO200	8.0
NOSO KO	9.2 13.2 13.3 10.4 3.2 2.0 1.2 0.7 0.5
7030	0.7
PEENS	1.2
FEEN SCA	2.0
6HT BET1	3.2
BY WEIG 21N. NE	10.4
EN CENT	13,3
21N. 1	13.2
31A.	17.5 9.2
. Z	7.
PCT (+)6 IN.SIZE	25.3
MOISTURE	2.2
MUCK DATA DRY UNIT WT PCF	136

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGULAR SMSUBANGULAR RMROUNDED PAPLATY CHCUBIC IMIRREGULAR EMLLONGATED SPASPHEROID

	FLOW TOUGHNESS INDEX	1.01	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREEY AT DE RCT MOIST	60
∢				\$
⋖	LOEX	2.70	BULK DENSITY PCF AT ST 0.0 PCT MOIST	
4	561N ICITY		IN APPARENT B ATE COMESTON D AT PSF AT P MOIST 2.0 PCT MOIST 0.	160
4	(-) 0.0 PLAST INDEX PCT	2.74		
4	5512E		IN 1DE 17E 17 40157	
₫.	PLASTIC SHRINKAGE PLASTICITY LINIT LIMIT PCT PCT PCT	15.12	ANGLE/REPOSE ANGLE/SLIDE ANGLE/SLIDE SOLIN DROP STEEL PLATE DEGREES AT DEGREES AT 3.1 PCT HOIST	31
4	ATTERI		E SI	
₫	ASTIC HIT	16.06	ANGLE/REPOSE 10 IN DROP DEGREES AT 3-1 PCT HOTST	
ď.	272		ANGLE 10 IN DEGREE	ž
₫.	LIOUID LINETS PCT	18.80	EF05E top 5 AT 7 H01ST	
4	POT VOL CHANGE (+)0.056 IN.SIZE		(-)0.75 IN.SIZE *SPECIF SPECIF GRAVITY OEGREES AT 3.1 PCT MOIST	9
	PO TOG	0	(-)0.75 SPECIF GRAVIT	2.84

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POWER SYSTEM	PUNP PRINARY SECONDARY 2400 440	SHOTCRETE	TORQUE,MAX/OPERATE THRUST,MAX/OPERATE HEAD CENTER KLB KFTLB KFTLB KFTLB	NUCE PER JUR.FI. BLASTING MUCKING GUIDANCE ELECTRICAL EIMCO TAILLESECOND 21 30-REGULAR	
UTILITY LINES	AIR WATER PU	SET.S1ZE.SHAPE	RPM HEAD.CENTER T	KERF SPACING ADVANCE PER FEET HOUR-FI. BLASTIN 30-REGU	
WATER INFLOW	GPH MINOR	. ROOF PLATE	DGES GAGE	0 FT	BASIS FOR MDW IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
	SIZE HP	SUPPORT SYSTEM BOLT.TYPE SIZE 6 FT X 5/8 IN	*DIAM*CUTTING EDGES INTERIOR GA	GUIDANCE THRUST/S KLB KLB EXPLOSIVES, POWDER FACTOR TOTAL LBS 140 PRIMERS, 9LB, INTERIOR ANFO CUT ANFO LIFTERS ANFO	YSIS AFTER WASHING UNLESS
VENTILATION	CFH PRESS EXHST 7K X	SUPPLY RAIL	CUTTERS+MAKE+TYPE+	ROUND. ROUND. ROUND. BEPTH 10 FT DIAM. 1.5 IN CUT. BURN5-2 IN SF/HOLE 1.6	DRY SCREEN ANALYSIS
>	GRADE BACK	PERSONNEL Rail Ail)- 3	MUCK SYSTE CAVATION CK HAMMER	BASIS FOR MON 15
TUNNEL	SIZE SHAPE 7F16IN ARCH 7F16IN	HAULAGE SYSTEM HUCK RAIL 1.5T ROCKER CAPS 40LB RAIL 18 IN GAGE 6 OR 8 T MOTORS	MACHINE EXCAVATION MACHINE MAKE MODEL	ANCHOR PRESS TELB CONVENTIONAL EX MACHINE JUMBO AIR LEG MACHINES 3IN JA P. EED LENGTH 6FT	

KEY 21a Tunnel data

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			PCT (-) NO200	•	SPHERO10				ž	
POISSON RATIO	0.17		NO160 NO260		Amangular s=subangular R=Roundeo P=Platy C=cubic i=irregular e=elongated sP=sPheroid		• • • • • • • • • • • • • • • • • • • •	_	SIZE(-)2.0 I ANGLE INTER PRICTION DEGREES AT 5.56 PCT MOIST	
YOUNGS NOD. PSIX10E6	12.26		0100	7.7	AR E=EL(Toughness	0.25	,	
	4	_	NO50	11.7	1 = IRREGUL	∢		5.3	BULK BULK BENSITY PCF AT S6 PCT MOIST	
SHORE SCHMIDI	4 %	CIMEM.	N030	7. N.	0=00ETC	4	FLOW	un .	N T N	
ROD PCT EST	90	3. UNPOLISMED SPECIMEM. 6. FROM CSM A.R.HO210743-72.	BETWEEN SCREENS	7.5 5.3) P=PLATY	4	.056IN STICITY	_	APPARENT COMESION PSF AT S.56 PCT MOIST	
CONP STRNTH KPS1	15	3. UNPOL	BETWEEN !	6.6	R=ROUNDEC	PA A1	126(-) 0.05 PLAST INDEX PCT	1,30		
ORY PCF	179	6610-66. Value. 6.	E I GMT NO4	12.3 6	JBANGULAR	ă 4 0	**************************************	22.92	SIZE(-)2.0 IN ANG!E/SLIDE STEEL PLATE DEGREES AT 5.56 PCT MOIST	
		M D.U.DEERE AD 646610-66. ASSIGNED MINIMUM VALUE.	PEG CENT BY W	21.3	BULAR S=SI	₫.	ATTERBERG LI SHRIN LIMIT PCT	25		
SCHIST		OM D.U.DE	:	3.5		PAI	• 6 6.	23.60	ANGLE/NEPOSE 10 ID DROP DEGREES AT 5.56 PCT HOIST	
ROCK PROPERTIES METAMORPHIC: MICA OCCASIONAL QUARTZ LAMINATIONS		FERRED FR	6IN. 3IN.	•	CREEN SIZ				. N	
ROCK PROPER METAMORPHIC OCCASIONAL LAMINATIONS		NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. 1	PCT(+)6		FRACTIONS BETWEEN SCREEN SIZES		LIGUID LIMITS PCT	24.90	ANGLEREPOSE 1 IN DROP DEGREES AT 5.56 PCT MOIST	
710M		FORMATION TOW TESTS,	STURE	•	RACTIONS		ANGE IN.SIZE			
IDENTIFICATION NEW YORK SAMPLE NO	•	II PCT. OF FEMPED FR	DATA UNIT MOIS PCF PCT	1 12.4	SHAPE OF F		POT VOL CHANGE (-)0.056 IN.S		(+)0.75 IN.SIZE SPECIF GRAVITY	
EY ID	•	NOTES:	# ORY	101	ℴ		ă.	•	ī in is	

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ES POWER SYSTEM	PUMP PRIMARY SECONDARY 6 IN 6600 440		APE SHOTCRETE	•	TORQUE . MAX/OPERATE THRUST. M . X/OPERATE	HEAD CENTER KIE KFILB KFILB KFILB KFILB KFILB KLB 953	ADVANCE PER HOUR+FT. 3.6		BLASTING MUCKING QUIDANCE		
OW UTILITY LINES	AIR WATER	*	SET.SIZE.SHAPE HALF CIRCLE BOLTED STEEL LAGGING IN FAULT ZONES		X Q	HEAD.CENTER 10.75	KERF SPACING ADVANC FEET HOUR 0.17		5	₹ 8*	1
WATER INFLOW	S12E HP GPH 20 IN 40 40	SUPPORT SYSTEM	BOLT,TYPE SIZE ROOF PLATE		DIAM.CUTTING EDGES	NTERIOR GAGE 18 REEO+3 DISC 6 JARVA TCB 18-3 DISC+0MC-3	GUIDANCE THRUST/SOFT KI LASER KLƏ 10.0		EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT	425	
VENTILATION	CFM PRESS EXHST 36K X	ns	SUPPLY BO Rail		CUTTERS.MAKE.TYPE.DI	CENTER INTER 2 REED 28 RE 5 DISC 0K-3 0K-1	POWER SYSTEM G		ROUND. NO. HOLES METH DIAM. CUT,	BASIS FOR MDW IS DRY SCREEN ANALYSIS NOTED BY (W) FOR SCREEN ANALYSIS WITH TRANSPORT SYSTEM CAPABILITY:CONVENTIO	The second of th
	SHAPE GRADE ROUND -0.30PCT	HAULAGE SYSTEM	PFRSONINEL RAIL RAIL I GAGE	MACHINE EXCAVATION	ñ	E MODEL WT	ANCHOR PRESS MUCK SYSTEM BUCKETS TO KLB	CONVENTIONAL EXCAVATION	N X 24	GASIS FOR MDN : NOTED BY (N) F(· -
TUNNEL	SIZE 11 FT	HAULAG	HUCK RAIL 17CY CARS 10T MOTORS 70LB RAIL 36 IN GAGE	MACHIN	MACHINE	B-46		CONVEN	MACHINE JUNBO MACHINES FEED LEW		

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22A TUNNEL DATA

POISSON RATIO	0.20
YOUNGS MOD. PSIX10E6	6.50
HORE SCHRIDT	45
SHORE	W.
PCT EST	96
COMP Strnth KPSI	13
0 2 g	111
ROCK PROPERTIES METAMOPPYIC: MICA SCHIST OCCASIONAL QUARTZ LAMINATIONS	
IDENTIFICATION VEW YORK SANOLE NO	2 - 12 2 - 12

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED'FROM D.U.DÉERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMIM VALUE. 6. FROM CSM A.R.HDZ10043-72. **KEY**

PCT (-) 10.0 61N, 31N, 21N, 11N, 1/21N, NOA NOB NOIG NOSG NOSG NOSG NOSG 9.8 14.6 9.1 6.9 9,2 5.6 10.6 13.3 2.2 PCT (+16 IN-512E MOISTURE PCT 7.2 MUCK DATA DRY UNIT WT PCF 16 SMAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGLAR SESUBANGUN AR REHOUNDED PEPLATY CECUBIC INTREGULAR EMELONGATED SPASPMEROID

TOUGHNESS	0.10	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 4.22 PCT HOIST	2.02
X S S S S S S S S S S S S S S S S S S S	5.70	ALK ENSITY EF AT MOIST	80.92
	•	MOTST	•
IZE(-) 0.09 PLAST INDEX PCT	9.68		
RG LIMITS.S SHRIMKAGE LIMIT	22.00	L 10C L A 7 E M 9 1	40.17
16 :08E		215	
PLASTIC LIMIT PCT	23,32	ANGLE/NEPOSE 10 IN UROP DEGREES AT	37.95
E LIBOURD	24.00	GREES AT	42.00
POT VOL CHANGE (-10.056 IM-SIZE	0	(-)0.75 IN.SIZE ". SPECIF AL GRAVITY DE	2.678
	PLASTIC SHRIM AGE PLASTICITY FLOW LIMIT LIMIT INDEX PCT	LIGNID PLASTIC SHRG LIMITS.SIZE(") 0.0501N FLOW LIGNID PLASTIC SHRIMMAGE PLASTICITY FLOW LIMITS LIMIT LIMIT INDEX PCT PCT FCT ACT 24.50 23.32 22.00 0.68 6.70	LIBUID PLASTIC SHRIG LIMITS.SIZE(-) 0.0561N LIMIT LIMIT LIMIT HODEX HODEX HODEX LIMIT LIMIT LIMIT HODEX L

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KEY									
23A TUNNEL DATA	ય								
TUNNEL		VENTILATION	NO1.		MATER INFLOW	UTILITY LINES		POWER SYSTEM	STER
SIZE SHAPE 8 FT ROUND 6 IN	GRADE +0.36PCT	16K	PRESS EXHST X	SIZE HP 12 IN 40	96 H	AIR MATER P	PUMP VI 4	Primary 6600	SECONDARY 440
HAULAGE SYSTEM				SUPPORT SYSTEM	*				
MUCK RAIL 13 CY CARS 10 T MOTORS 70 LB RAIL 36 IN GAGE	PERSONNEL RAIL	й&	SUPPLY RAIL	BOLT.TYPE SIZE	E ROOF PLATE	SET.SIZE,SHAPE HALF CIRCLE BOLTED STEEL LAGSING IN FAULT ZONES	6_160 S	SHOTCRETE	
MACHINE EXCAVATION	T10N								
MACHINE		CUTTERS	CUTTERS.MAKE.TYPE.	DIAM.CUTTING EDGES	EDGES	n da	TORQUE.MAX/OPERATE	OPERATE	THRUST. WAK/OPERATE
MAKE HODEL JARVA 8-806	ZA ZA	CENTER 2 REED TOOTH TYPE		INTERIOR 12 REED QC-3 TCB BUTTON	GAGE 3 JARVA DISC GKC-3W• TCB	HEAD.CENTER 12.5	HEAD KFTLB 158 KFTLB	CENTER KFTLB KFTLB	284 485 KL8 KL8
48									
ANCHOR PRESS	MUCK SYSTEM BUCKETS TO BELT	POWER	POWER SYSTEM	GJIDANCE THRU Laser Klb	8.49	KERF SPACING ADVANCE PER FEET HOUR.FT. 0.09 3.1	#		
CONVENTIONAL EXCAVATION	XCAVAT TON								
MACHINE JUMBO MACHINES FEED LENGTH	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	ROUND. NO. HOLES DEPTH DIAM. CUT.		EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT	S ACTOR	4	BL AST ING	MUCKING	GUIDANCE
40 2 F L +	BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UMLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RA FREE VEHICLES YES BELT CONY. (2) HYDRAULIC PIPELINE YES PHOSSIBLE.TECHNOLOGY NOT FUALY DEVELOPED. (2) EXCESSIVE F	S DRY SCR R SCREEN R CAPABIL ES BELT (OLOGY NO)	REEN ANALYS ANALYSIS W ITT:CONEN CONY. (2) H I FULLY DEV	IS AFTER WASH ITH NATURAL M TIONAL RAIL YORAULIC PIPE	BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE YEHICLES YES BELT CONY. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES* *POSSIBLE:TECHNOLOGY MOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.	PIPELINE YES* Loup Probable.		E NA	CURRENT: 04/01/73

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POISSON RATIO	0.25 NOTE
YOUNGS MOD. PSIX10E6	4.50 NOTE
SHORE SCHNIDT	30
SHORE	4
800 PCT E3T	8
COMP STRNT: KPSI	=
ORY PCF	165
METAMORPHICS GRAY MICA SCHIST OCCASIONAL QUARTZ SEAMS, MICA VARIES FROM DENSE, FINE	GRAINED TO EXTREMELT COARSE.
KEY IDENTIFICATION 24 QUEEN LANE SAMPLE NO	ok-1

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.H0210943-72.

PCT (-) NO200	20.9
**************************************	7.7
NOS0 NOI	0.0 7.6 17.0 13.4 4.5 4.9 5.4 8.4 10.2 7.7
NO36	4.0
N SCREENS	Q. 4
16HT BETWEE	Q. 4
ENT BY WEI	°.0 13.4
IN. IIN.	7.6 11
31N. 2	0.0
PCT(+)6 ****	
	••
DATA UNIT HOISTURE PCF PCT	0 • 0
¥ 60 F	109

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A MANGULAR SESUBANGULAR REROUNDED PEPLATY CHCUBIC INTRREGULAR EMELONGATED SPASPHEROID

	TOUGHNESS	0.17	SIZE(-)2.0 IN. ANGLE INTER FRECTION DEGREES AT DEGREES AT 0.3 PCT HOIST	30
=			• • •	5
Ĭ.	FLOE	••	BULK BULK DENSITY PC= AT 0.0 PCT MOIST	•
.			APPARENT COMESICH PSF AT -3 PCT MOIST	125
ē.	PCTO	0.7	¥ 15	
ā	75512E		IN LATE AT HOIST	
I d	BERG LIMI SHRINKA LIMIT PCT	22.7	ZE(~)2.0 ANGLE/SI STEEL PO DEGREES 8.4 PCT	9
PE	ATTER		IAL SI ST	
PE	PLASTIC SHRINKAGE PLASTICITY PLASTICITY PLASTICITY PCT PCT	23.3	ANGLE/REPOSE ANGLE/SLIDE ANGLE/SLIDE ANGLE/SLIDE ANGLE/SLIDE ANGLE/SLIDE STEEL PLATE DEGREES AT DEGREES AT 9.8 PCT MOIST 8.4 PCT MOIST	. 37
	LIGUIO	24.0	E/REPOSE DROP EES AT PCT MOIST	
	POT VOL CHANGE (-)0.056 IN.SIZE	6	(*)0.75 IN.SIZE ************************************	2.57 39

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STEX	SECONDARY 480V		THRUST . MAX/OPERATE RLB 377 RLB 377	CURRENT: 04/01/73
POWER SYSTEM	PRIMARY 4150 V	SMOTCRETE	CENTER KFTLB KFTLB KFTLB KFTLB	AL-1 PNN S
UTILITY LINES	AIN WATER PUMP AIN	SET.SIZE.SHAPE OCCASIONAL SEMI- CIRCULAR PLATES PINNED AT SPING LINE AT FAULTS	RPM TOROUE.MAX/OPERATE HEAD.CENTEP HEAD CEN SC KFTLB KFTLB KFTLB 244 KFTLB KFFLB 250 KFTLB 244 KFTLB FEET HOUR.FT. 6.18 2.9	C. PIPELINE YES*
WATER INFLOW	S12C HP GPN 14IN	SUPPORT SYSTEM BOLT.TYPE SIZE ROOF PLATE	EDGES GAGE GAGE 6 REED ST TRIPLE DI RUST/SQ FT RUST/SQ FT ACTOR BS	LIFTERS FISS AFTER WASHING UMLESS WITH NATURAL MOISTURE. ENTIONAL RAIL YES SIDE RAIL YES* HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES* EVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
NOTIFICATION		SUPPLY RAIL	CUTTERS, MAKE, TYPE CENTER Z REED STEEL TRIPLE DISC TR	BASIS FOR MDN IS DRY SCREEN AMALYSIS IN TRANSPORT SYSTEM CAPABILITY:CONVERTREE VEHICLES VES BELT CONV. (2) PREC VEHICLES VES BELT CONV. (2) PREC VEHICLES VES BELT CONV.
•	SIZE SHAPE GRADE 11FT ROUND +1-3PCT	HAULAGE SYSTEM Huck Rail Rail	ACHINE EXCAVATION AACHINE MAKE MODEL WI JARVA 11-1100 TON KLB 3402 CONVEYOR BELT TO RE JUMBO MACHINES FEED LENGTH	BASIS FOR MDN NOTED BY (N) 1 TRANSPORT SYST FREE VEHICLES *POSSIBLE*TECT
,	- 07 =4	1 411	B-50	

B-50

KEY 24A TUNNEL DATA

POISSON RATIO	0.20
YOUNGS POISSON I MOD. RATIO PSIXIOCE	9.16
SHORE SCHNIDT	:
SHORE	¥ 2
900 FCT	35
COMP STRN1H KPS1	25
P E E	171
ROCK PROPERTIES SEDIMENTARY. GRAYWACKE (ARGILLACEOUS QUARTZITE) MASSIVE TO MEDIUM BEDDED.	HIGHLY FOLDED AND FRACTURED NORMAL DIP OF BEDDING 30 PEGREES TO 45 DEGREES
KEY IDENTIFICATION 25 MR SAMPLE NO	Z~9#

如果我们就是我们的一个时间,我们就是我们的一个时间,我们就是我们的一个时间,我们就是我们的一个时间,我们也会会会会会会会会会会会会会会会会会会会会会会会会会会会 第一个时间,我们就是我们的一个时间,我们就是我们的一个时间,我们就是我们的一个时间,我们就是我们的一个时间,我们就是我们的一个时间,我们就是我们的一个时间,我们

NOTES: 1. 80 PCT. OF FORMATION. ?. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

PCT (-) NO200	1.7
**************************************	4.0
NO100	19.2 24.5 19.9 13.2 3.8 2.7 1.6 0.8 0.7
NOSO	•
N030	9.6
SCREENS NOT 6	2.7
BETWEEN NOS	3.8
Y WEIGHT	13.2
1 CENT 8)	19.9
IN. 1IN	24.5
2	19.
61N. 31N.	12.5
PCT (+)6 IN-SIZE	0.0
MOISTURE PCT	2.1
DATA	102
MUCK DRY MT	

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A MANGULAR SASUBANGULAR RAROUNDED PAPLATY CHCUBIC, IMIRHEGULAR EMELONGATED SPASPHEROID

			0.0	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 1.58 PCT HOIST	42.5
	™ ∢	FLOW TODEX	~	APPARENT BULK CCHESION DENSITY PSF AT PCF AT 1.58 PCT MOIST 1.58 PCT MOIST	96.36
	4	•	7.2	BULK BULK DENSITY PCF AT IST 1.58 PCT	
	14	oitv.		APPARENT CCHESION PSF AT SB PCT HO	250
	AIE	(-) 0.05 PLASTI INDEX PCT	0.22	INAPPARENT SE CCHESION I PSF AT OIST 1.50 PCT #	
	APIE APIE	SS1ZE		IN TSE ATE AT MOIST	24
		PLASTIC SHRIMKAGE PLASTICITY LIMI LIMIT PCT PCT	16.73	ANGLE/REPOSE ANGLE/SLJSE IN ANGLE/SLJSE IN IN DROP STEEL PLATE DEGREES AT DEGREES AT I.58 PCT MOIST	31.42
	AP 1 APE	ATTER	_	FRIAL SI POSE POSE NT 101ST	
	APE	PLASTI LIMIT PCT	17.48	ANGLE/REPOSE 10 IN DROP DEGREES AT	33,25
	APE	LIGUID LIMITS PCT	17.70		
				(-)0.75 IN.SIZE ************************************	35.75
		POT VOL CHANGE (-)0.056 IN.SIZE		IN. SI	
•		POT V(•	SPECII GRAVII	2.678

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04/01/13	
CURRENTS	
M8-2	NON 7

3759	SECONDARY 480				THRUST.HAX/OPERATE		7.7 8.0	
POWER SYSTEM	Prinary 2300		SHOTCRETE		TORQUE.MAX/OPERATE	CENTER	XX 411 811 8	
UTILITY LINES	MATER PUMP		SE1.51ZE.SHAPE		TORQUE+M	HEAD.CENTER HEAD	KF1L8 KF1L8	ADVANCE PER HOUR of To
	AIR WATER				Mda	HEAD+C		KERF SPACING FEET
WATER INFLOW	GPM NONE	*	E ROOF PLATE AS REGUIRED		EDGES	GAGE		JST/SQ FT
	SIZE HP 16 IN 30	SUPPORT SYSTEM	HOLT.TYPE SIZE S FT X .75 IN		DIAM.CUTTING (INTERIOR		GUIDANCE THRI
VENTILATION	EXHST X		SUPPLY		CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	-		POWER SYSTEM
VENI	GRADE CFH +2.0 PCT BK		PERSONNEL RAIL	_	CUTT	WT CENTER		MUCK SYSTEM
TUMNEL	SIZE SMAPE 10 FT RECT 10.8 FT	HAULAGE SYSTEM	MUCK RAIL 140-200CF R BOTTOM DUMPCARS 60-80LA RAIL 10 T MOTOR 30 IN GAGE	MACHINE EXCAVATION	HACHINE	MAKE MODEL		ANCHOR PRESS MUC KLB

CONVENTIONAL EXCAVATION

B-52

MACHINE JUMBO 2 BOOM MACHINFS D=93	ROUND. NO. HOLES 36 DEPTH & FT	EXPLOSIVES. POWDER FACTOR 7.5LB/CY TOTAL LBS 210	BLASTING IGNITER CORD FUSE CAPS
1 1/4 STEEL	CUT. V	TRIM ANFO	
reed Length 1971	SF/HOLE 2.6	CUT AMFO TITEBE AND	

BUIDANCETRANSIT

HUCK ING ETHCO 40

BASIS FOR MEN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTHRE. THANGOURT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES. FREE VEHICLES YES BELT CONV. YES HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO **POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED.

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25A TUNNEL DATA

POISSON RATIO	0.25
YOUNGS MOD. PSIX10E6	3.38
SHORE SCHMIDT	37
SHORE	6.1
80D TO T	95
COMP STRN1H KPS1	22
DRY #1 PCF	166
ROCK PROPERTIES SEDIMENTART: SANDSTONE FINE GRAINED. WELL COMPACTED. LIGHT BROWN OVER SO PCT	O JASTZ.
KEY IDENTIFICATION 26 5-1 SAMPLE NO	3-1

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEFRE AD 646610-66. 3. UMPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HO210043-72.

PCT (-)	11.8
ZIN. 11N. 1/ZIN. NO4 NOB NO16 NO30 NO50 NO100 NO200	0°.
NO50	33.8 20.9 15.5 4.4 2.7 1.3 1.1 3.5
N030	1.1
REENS	1.3
NOB I	2.7
116HT BE	4.4
INT BY WE	.9 15,
PER CE	33.8 20,
IN. 2IN	0
ern. 3IN.	0
PCT(+)6 IA+SIZE	0.0
MO1STURE PCT	\$. \$
MUCK DATA DRY UNIT	83

SHAPE OF FRACTIONS BETWEEN SCHEEN SIZES AMANGULAR SESUBANGULAR REROUNDED PEPLATY CECUBIC IMIRREGULAR EMELONGATED SPASPHEROID

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OUGHNESS NDEX	0.28	SIZE(-)2.6 IN. ANGLE INTER FRICTION DEGREES AT	6 N
FLOW TOUGHNESS INDEX INDEX	5.0	BULK DENSITY PCF AT IST 0.0 PCT MOIST	85.23
(-) 0.1851NPLASTICITY INDEX	1.40	APPARENT COMESION PSF AT 4.8 PCT MOIST	280
PLASTIC SHRIMS.SIZE(-) 0.1851N PLASTIC SHRIMKAGE PLASTICITY LIMIF LIMIF PCT PCT	15.18	ANGLE/REPOSE ANGLE/SLIDE APPARENT 10 IN DROP STEEL PLATE COMESION DEGREES AT PSF AT 6.3 PCT MOIST 6.3 PCT MOIST	58
PLASTIC LIMIT PCT	15.50	ANGLE/REPOSE 10 IN DROP DEGREES AT 6.3 PCT MOIST	58
LIOUID LIMITS PCT	16.90	(-)0.75 IN.SIZE ************************************	35
POT VOL CHANGE	ø	(-)0.75 IN.SIZE SPECIF GRAVITY	2.73

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STEM	SECONDARY 480V				THRUST.HAX/OPERATE	KLB 1580 KLB 914			GUIDANCE		CUPRENT: 04/01/73
POWER SYSTEM	PRIMARY 4160V		SHOTCRETE		COPERATE	CFNTER KFTL9 KFTL9			WUCK [NG		101 101 101
UTILITY LINES	AIR WATER PUMP 21N 41N		SET.SIZE.SMAPE		RPM TORQUE, MAX/OPERATE	HEAD.CENTER HEAD 4.5 INTEG KFTLB1720 KFTLB	ACING ADVANCE PER HOUR-FI.		BL ASTING		PIPELINE YES* Dup probable.
WATER INFLOW	E HP GPM N 75 5-10	SUPPORT SYSTEM	######################################		• CUTTING FOGES	INTERIOR GAGE 43 ROBRINS. 12IN STEEL 12IN STEEL DISC DISC	GUIDANCE THRUST/SO FT KERF SPACING LASER KLB 3.56 0.20		EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS. TRIM	INTERIOR CUI LIFTERS	BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYS("M CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES YES BELT COMV. (2) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE YES* *POSSIBLE*TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
VENTILATION	CFM PRESS EXHST SIZE	ddNS	SUPPLY BOLT DIESEL 4-5/ TRUCKS• JEEPS		CUTTERS.MAKE.TYPE.DIAM.CUTTING FDGES	CENTER INTER 1 ROBBINS, 43 RD 7.SIN TRIPLE 12IN STEEL DISC DISC	POWER SYSTEM 6-200HP MOTORS FOR WEAD		ROUMD. NO. HOLES DEPTH CUT.		BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WANDED BY (N) FOR SCREEN ANALYSIS WITH NATURAL TRANSPORT SYS! M CAPABILITY:CONVENTIONAL RAILFREE VEHICLES YES BELT CONV. (2) HYDRAULIC PIGNOSSIBLE:TECHNOLOGY NOT FULLY DEVELOPED. (2)
EL	SMAPE GRADE T ROUND -7.0PCT	AGE SYSTEM	MUCK PERSONNEL 30IN PIGGYBACK OIESEL CONVETURS. 36IN TRUCKS. SUSPENDED JEEPS CUNVEYOR	MACHINE EXCAVATION	i Ni	MAKE MODEL WT KOBBINS 181-122 266 TONS	ANCHOR PRESS MUCK SYSTEM BUCKETS FROM RLB FACE. 30 IN CONVEYOR TO REAR	CONVENTIONAL EXCAVATION		FEED LENGTH	BASIS FOR MDN IS NOTED BY (N) FOR TRANSPORT SYSCIM FREE VEWICLES YES
TUNNEL	512E 18 FT 1 IN	HAULAGE	X	MACH	MACHINE	₹º B-54	ANC.	CONV	MACHINE JUMBO MACHINES	FEED	

B-54

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26A TUNNEL DATA

POISSON RATIO	0.25
YOUNGS MOD. PSIXIOE6	5.38
HORE SCHIDT	37
SHORE	61
# # # # # # # # # # # # # # # # # # #	26
COMP STRNTH KPSI	25
P K D	166
ROCK PROPERTIES SEDIMENTARY: SANDSTONE FINE GRAINED: WELL COMPACTED: LIGHT BROWN: OVER 50 PCT	GUARTZ.
KEY IDENTIFICATION 27 7-2 SAMPLE NO	7-2

6. FROM CSM A.R. HOZIOD43-72. NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6

PCT (-) NO200	10.7
. 21N. 11N. 1/21N. ND4 NOB NOIG NO30 NOSO NOIGG NOSO	∞ .
NOSON OSON	33.1 22.6 15.4 4.3 2.6 1.4 1.2 2.5 3
NO30	1.4
EEN SCREENS 08 NO16	2.6
HT BETW	* .3
T RY WEIG	15.4
PER CEN	.1 22.6
S S	9 33
61N. 3KN.	1.5
PCT (+)6 IA-SIZE	0.0
MOTSTURE PCT	0-4
HUCK DATA DRY UNIT WI PCF	vo

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPWERG:O

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0.18	SIZE(+)2.0 IN. ANGLE INTER FRICTION DEGREES AT 2.8 PCT MOIST	;
96.5	SULK SULK SENSITY OF PET MOIST	95.8
5.37	APPARENT COMESION DSF AT PSF AT 2.0 PCT MOIST 0.	G
17.58	SIZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 2.6 PCT NOIST	56
17.63	AMGLE/REPOSE 10 IN DROP DEGREES AT 2.6 PCT MOIST	33
23.0	GLE/REPOSE IN DROP GREES AT PCT MOIST	32
	0.75 IN.SIZE 4. FCIF AN AVITY DE! 2.6	2.63
	17.63 17.58 5.37 6.90	17.63 17.58 5.37 6.90 0.78 WATERIAL SIZE(-)2.0 IN

CURRENT: 04/01/73

7-2

STEE	SECONDAPY 480V				THRUST . MAX/OPERATE	Kie 1560 Kie 747			GUIDANCE	CURRENT: 04/81/73
POWER SYSTEM	PRIMARY 4160 <		SHOTCRETE		(/OPERATE	CENTED KFTLB KFTLB	,	,	MUCK 114G	7 10 10 10 10 10 10 10 10 10 10 10 10 10
UTILITY LINES	AIR WATER PUMP ZIN 41N		SET • S1ZE • SMAPE		RPM TOROUE.MAX/OPERATE	HEAD-CENTER HEAD 4.5 INTEG KFTLB1720 KFTLB	ACING ADVANCE PER HOUR FT. A.4.		BLASTIN G	SA PAELWAIIC PIPELINE VES® FINES BUILDUP PROBABLE.
WATER INFLOW	6₽H 5-10		R00F PLATE 8.2LB CHANNEL 61N x 9.5FT OR 13.5FT AT 4FT OR 2FT		GES	GAGE Robbins 12 in Steel disc	THRUST/SO FT KERF SPACING FEET KLB 2.91 0.20		φ Q	G UMLESS STURE. SIDE RAIL YES* INE NO PNEUNATIC ESSIVE FINES BUIL
	SIZE HP 36IN 75	SUPPORT SYSTEM	80LT.TYPE 512E 4-5/81N X 4FT		DIAM. CUTTING EDGES	INTERIOR 41 ROBBINSIZIN STEEL DISC	GUIDANCE THRU LASED KLB		EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT	IS AFTER WASHIN ITH NATURAL MOI TIONAL RAIL YES "JRAULIC PIPELI ELOPED" (2) EXC
VENTILATION	CFM PRESS EXHST 17K X	Vi	SUPPLY DIESEL 4 TRUCKS•		CUTTERS.MAKE.TIPE.	CENTER 1,51N 4,1 ROBBINS 7,51N 4,1 TRIPLE STEEL SI	POWER SYSTEM 4-200HP HOTORS FOR HEAD		ROUND. NO. HOLES DEPTH DIAM. CUT.	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UMLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YESFERE VEHICLES YES BELT COMV. (2) H.DRAULIC PIPELINE NO PNEUMATIC POSSIBLE,TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUT
	GRADE +2.0PCT		PERSONNEL DIESEL Trucks Jeeps	¥0		81 286 10NS	MUCK SYSTEM BUCKETS FROM FACE - 391N CONVEYOR TO REAR	EXCAVATION	ROLWD. NO. HO DEPTH DIAM. CUT.	S FOR MON IS D BY (N) FOR SPORT SYSTEM VEWICLES YE SIELE TECHNO
TUNNEL	SIZE SHAPE 18FT ROUND 11N	HAULAGE SYSTEM	MUCK 301N PIGGYBACK CONVEYOR+ 36IN SUSPENDED CONVEYOR	MACHINE EXCANATION	MACHINE	MAKE HODEL HOBEL H	ANCHOR PRESS ME BI KLB FI	CONVENTIONAL EXC	MACHINE JUMBO MACHINES FLEF LENGTH	BASI: NOTEI TRAN: FREE POSS

KEY 27a TUNNEL DATA

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			PCT (-) NO200	0	SPHERO10				ž. ts	
POISSON RATIO			NO200		A=ANGULAR S#SUBANGULAR R#ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP#SPHEROID		• • • • • • • • • • • • • • • • • • •		SIZE(-)2.0 IP ANGLE INTER FRICTION DEGREES AT 0.2 PCT MOIST	;
YOUNGS #00. PSIX10E6	5.52		0010		IR E=EL	4	TOUGHN	0.26		
	> 4		NO30 NOSO NOIGO NOSOO		IRREGULA		FLOW TOUGHNESS THOSE INDEX		IITY PCT MOIST	100
SHORE SCHILL	ਜ਼ੂ . *	N. 3-72.	9	*:	UBIC 1#	4	FLOW	3.00		
	PARALL 41-55. NORMAL 41-54. MT. AV.	SPECINE H021004	SS	2 . 0	ATY CEC	•	3		ON T MOIST	550
PCT FST	* * * *	SM A.R.	SCREEN NO 16	8° E	10 P#PL	⋖	0.056IN.PLASTICITY INDEX	•	APPARENT COMESION PSF AT 0.2 PCT M	M.
COMP STRNTH KPSI	4 MAJ BEDS 22 to 29 3 min Beds 12 to 17 WT. AV. 23	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.H0210043-72.	PER CENT BY WEIGHT BETWEEN SCREENS IN. 11N. 1/21N. NO4 MOB NO16 (7.3	r-round		1ZE(-) 0 PLA IND PCT	0.10		
DR. PCF			WE16HT	16.4 5	NGULAR	•	PLASTIC SHRINKAGE PI PLASTIC SHRINKAGE PI LIMIT LIMIT PCT PCT	=	E-SLIDE E-SLIDE E-SLIDE PET PLATE PCT MOIST	8
	165	AD 645610-66. IIMUM VALUE.	ENT BY T	16.9	S#SUBA	4	BERG LIV SHRING LIMIT PCT	14.51	SIZE(~)2.0 ANGLE/SLIDE STEEL PLATE DEGREES AT 1.0 PCT HOT	
TVE TO EDDED H	PCT.	DEERE A ED MINI	PER C	14.4 14	angul ar	Vd Vd	ATTER			
ROCK PROPERTIES SEDIMENTARY: SMALE, MASSIVE TO THIMEY LAMINATED, INTERECDED SILTSTONE AND SMALE, WITH	MO LINE TE FINE TO 33	FRON D.U.DEERE AD 645610-66 5. ASSIGNED MINIMUM VALUE.	~	11.3	IZES A:	₹ 2	PLASTI LIMIT PCT	14.81	ANGLE/REPOSE 10 IN DROP DEGREES AT 1.0 FCT MOIST	ş
ERTIES 271 SHAL 11NATED	STONE A	PRED FE	61N. 31N	12.6	S	4	•		200	
CK PROPI DIMENTA INLY LA LTSTONE	vor sam Yers G Nrse G	Z. INFI MILAR RI			TWEEN SI		LINITS PCT	15.60	ANGLE/REPOSE 1 IN DROP DEGREES AT 0 PCT MOIST	
SES	ī Šē	ATION. ESTS/SI	E PC1(+)6 IN-S17E	f.	IONS BE	đ	12E			%
CAT10N 0		OF FORM	HOISTURE PCT	1-1	SHAPE OF FRACTIONS BETWEEN SCREEN		POT VOL CHANGE (-)0.056 IN.SIZE		IN.SIZE	
IDENTIFICATION 11-3 SAMPLE NO	11-3	NOTES: 1. 60 pm, of formation. 2. Inferred 4. Inferseu from TESTS/SIMILAR ROCK.	DATA UNIT POF	\$	SHAPE 0		POT VOL	•	(+)0.75 IN.SIZE SPECIF GRAVITY	2,65
KE7 28 1	_	NOTE	MUCK DRY TH	v					-	

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04/01/73
CURRENT :
11-3 MDN 2

SECONDARY 10V	-			THRUST + MAK/OPERATE		X X X Y Y Y			GUIDANCE Transit Laser Taser	CUARENT: 04/01/73
PRIMAR'		SHOTCRETE		K/OPERATE	CENTER	KFTL8 KFTL8	-		MUCK ING SCOOPTRAN	11-3 MON 2
MATER PUMP		SET.512E.SHAPE		TORQUE • MAX/OPERATE	HEAD.CENTER HEAD	MF1LB KF1LB	VG ADVANCE PER MOUR•FT•		BALASTING ELECTRICAL M.S. DELAYS TE SY L 60PCT	ELINE NO Damage.
GPH AIR NONE 4IN		ROOF PLATE SET		ES RPM	GAGE HE		THRUST/SQ FT KERF SPACING KLB		EXPLOSIVES. POWDER FACTOR 3.5LB/CY TOTAL LBS 234 PRIMERS. 16LB 1.25IN X BIN. 75PCT PRIM 11LB 1.25IN X 12IN. COALITE SY INTERIOR ANFO CUT	· UNLESS SIDE RAIL YES* SIDE RAIL YES* E NO PNEUMATIC PIPELINE NO SSIVE HIDTM: WEAR: DAMAGE.
S12£ HP	SUPPORT SYSTEM	80L1+TYPE SIZE 5/81N X 6FT 4FT X 4FT PATTERN		CUTTERS,MAKE.TYPE.DIAM.CUTTING EDGES	INTERIOR		GUIDANCE THRUS			YSIS AFTER MASHING UMLESS WITH NATURAL MOISTURE. ENTIONAL RAIL YES SIDE RAIL YES* HYDRAULIC PIPELINE NO PNEUMATI EVELOPED. (1) EXCESSIVE WIDTH. M
CFM PRESS EXHST 40-100K X		SUPPLY DIESEL TRUCKS. JEEPS		CUTTERS.MAKE.TYPE	CENTER		POWER SYSTEM		ROUND. NO. HOLES 35 DEPTH :0.5FT - 11FT DIAM. 1-3/4IN CUT. 1-6FT BUSTER HOLE SF./HOLE 5.1	BASIS FOR MDN IS DRY SCREEN AMALY: NOTED BY (N) FOR SCREEN ANALYSIS I TRANSPORT SYSTEM CAPABILITY:CONVE! FREE VEHICLES (3) BREI CONV. (1) *POSSIBLE:TECHNOLOGY NOT FULLY DE' (3) EXCESSIVE TIRE WEAR PROBABLE.
GRADE Varies		PERSONNEL DIESEL TRUCKS. JEEPS	NOI		L WT		MUCK SYSTEM	CAVATION	DROJIB TERS	IS FOR MON ED BY (N) FI NSPORT SYSTE E VEHICLES SSIBLE FECH
SIZE SHAPE 24FIX7 RECT .SFISFI	HAULAGE SYSTEM	MUCK MAGNER ST-5 SCOOPTRAM. 16TON SHUTLE. CARS	MACHINE EXCAVATION	MACHINE	MAKE MODEL	B-58	ANCHOR PRESS KLB	CONVENTIONAL EXCAVATION	MACHINE JUMBO Z BOOM HY MACHINFS 2-AR93 DRIF FEED LFNGTH 14FT	BARATARA PER

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POWER SYSTEM

UTILITY LINES

WATER INFLOW

VENTILATION

28A TUNNEL DATA

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			FCT C	1.3	SP=SPHERO10					_
P01550N RATIO	00.18 4 ATE				NGATED SP		• • • • •		SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 0.2 PCT MOIST	
YOUNGS HOD. PSIX10E6	9.50 NOTE 4		NO30 NOS0 NO100 NO200	0.2	P=PLATY C=CUBIC I=IRREGULAR FBELONGATED		TOUGHNESS	9.05		
ESS	* *		NO50	0.0	I=IRREGU	⋖	э́й Х	•	BULK DENSITY PCF AT 0.0 PCT MOIST	
SHORE SCHMIDT	PARALLEL 41-55. Norkal 41-54. 48	IMEN. 0043-72.	N036	9•0	C*CUBIC	<	FLOW	4.60	ist ø	
R00 PCT S	90 414 414 1014	HED SPEC A.R.H021	SCREENS	1.2	D=PLATY	•) 0.056IN PLASTICITY INDEX PCT		AAR AAR AT OT	
COMP STRWTH KPS1	4 HAJ BEDS 22 TO 29 3 MIN BEDS 12 TO 17 HT. AV. 23	3. UMPOLISHED SPECIMEN. 6. FROM CSM A.R.M0210043-72	BETWEEN SC NOS	2.5	S#SUBANGULAR R=ROUNDED	⋖	F(-) 0.0 PLAST INDEX PCT	0.20	•	
	4 0 E M E	Š	WEIGHT BE	7 3.4	ULAR REI	d	PLASTIC SHRINKAGE PI PLASTIC SHRINKAGE PI LIMIT LIMIT PCT P		IN LLATE : AT : HOIST	
DRY ET PCF	166	646610-66. UM VALUE.	CENT BY WE	7 12.7	S=SUBANG	4	ERG LIMI SHRINKA LIMIT PCT	13.26	SIZE(-)2.0 ANGLE/SLIDE STEEL PLATE DEGREES AT 0.9 PCT HOE	
IVE TO EDDED MINOR	E VERS	DEERE AD ED HINIM	ZIN. 11N.	19.3 15.7	A=ANGULAR	4	• ATTERBI		11AL S121 15E 11ST (
E. MASSIVE INTERBEDDE LE WITH MIN	KESTONE L O COARSE	OM D.U.C		17.0 19	SES	4	•	15.60	ANGLE/REPOSE 10 IN DROP DEGREES AT 0.9 PCI MOIST	
ROCK PROPEPTIES SEDIMENTARY: SHALE. THINLY LAMINATED. IN STLISTOME AND SHALE	SANDSTONE AND LIMESTONE LAYERS GRAIN SIZE FINE TO COARSE. JUARTZ 24 TO 33 PCT.	NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-60 1. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE.	6IN. 3IN.	17.7	IS	₹	•			
ROCK PROPERTIES SEDIMENTARY: SHI THINLY LAMINATES	iadstone Pata sizi Brtz 24	2. INFI HILAR R			SHAPE OF FRACTIONS BETWEEN SCREEN		LIOUID LIMITS PCT	15.80	REPOSE ROP S AT T HOIST	
2012	% & &	44110K. TESTS/S1	RE PCT(+)6 IN-S17E	8.2	TIONS BE	4	\$1 2 €		ANGLE/REPOSE 1 IN DROP DEGREES AT 0.9 PCT MOIS	
IDENTIFICATION 11-4 SAMPLE NO		OF FORI	MOISTURE PCT		OF FRACI		POT VOL CHANGE (-10.056 IN.SIZE		(-)0.75 IN.SIZE SPECIF GRAVITY	
IDENTIF 11-4 SAHPLE	1	NOTES: 1. 80 PCT.	CK DATA	96	SHAPE		POT VO	•	SPECIF SPECIF GRAVITY	
KEY 29		NO.	TUCK DRY TH		D 56					

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rsten	SECONDARY 600V		THRUST+MAX/OPERATE	KL8 1.003		GUIDANCE	CURRENT & -64/01/73
POWER SYSTEM	PRIMARY 4160V	SHOTCRETE	TORQUE.HAX/OPERATE	CENTER AFTLB AFTLB		MUCKING	11-4 MON 2
UTILITY LINES	AIR WATER PUMP 21N	SET+S12E+SHAPE	RPM TORQUE.	MEAD.CENTER MEAD 3 1/4UPPER 1 5-8LOWER KFTLB KFTLB	KERF SPACING ADVANCE PER FEET HOUR.FT. NA NA	BLAST ING	SSS RAIL YES* PNEUMATIC PIPELINE NO E WIDTH+ WEAR+ DAMAGE.
WATER INFLOW	SIZE HP GPM 40 NONE	SUPPORT SYSTEM BOLT-TYPE SIZE ROOF PLATE 5/81N X 6F1 AT 4FT X 4FT	*DIAM*CUTTING EDGES	INTERIOR GAGE CUTTERS MOUNTED ON 4 ROTATING	GUIDANCE THRUST/SO FT KERF STRANSIT KLB NA FEI LASER N.B. NA	EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS. TRIM INTERIOR CUT	IS AFTER WASHING UNLESS ITH NATURAL MOISTURE. TIONAL RAIL YES SIDE RAIL YES. YDRAULIC PIPELINE NO PNEUMATI ELOPED. (1) EXCESSIVE WIDTH.
VENTILATICN	EXHST	NNEL SUPPLY L DIESEL TRUCK	CUTTERS.MAKE.TYPE.D	WI CENTER IN 180 48 T.C. DRAG CU L.T. HEADS	TEM POWER SYSTEM DNVEYOR 4-80KW MOTORS EL + HEAD ROIATION VEYOR 2-70KW MOTORS HYDRAULICS	ROUND. NO. HOLES DEPTH DIAM. CUT.	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UMLES NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL HOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE FREE VEHICLES (3) BELT CONV. (1) HYDRAULIC PIPELINE NO *POSSIBLE,TECHNON.OGY NOT FULLY DEVELOPED. (1) EXCESSIVE (3) EXCESSIVE
TUNNET	SHAPE	HAULAGE SYSTEM MUCK DIESEL SHUTTLE DIESE CAR. CONVEYOR TRUCK HACHINE EXCAVATION	HACHINE	MAKE MODEL ATLAS - 4-HEAD COPCO	ANCHOR PRESS MUCK SYSTEM IS 1000 STAR WHEN CONVENTIONAL EXCAVATION	MACHINE JUMBO NACHINES FEED LENGTH	BASIS FINOTED B TRANSPOINT FREE VEI FREE VEI (3) EXCISE

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POWER SYSTEM

29A TUNNEL DATA

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POISSON RATIO	0.35
YOUNGS MOD. PSIX10E6	8.37
SHORE SCHMIDT	9
SHORE	41-55
800 PCT EST	99
COMP STRNTH KPSI	25
PCF	168
ROCK PROPERTIES SEDIMENTARY: SHALE INTERMEDED SILTSTONE • SHALE MINOR SANDSTONE	+ LIMESTONE, FINE TO COURSE GRAINED
IDENTIFICATION 72-1 CAMPIF NO	72-1

KEY 30

NOTES: 1. BO PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UMPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZIGO43-72.

PCT (-)	e.	98.	P#SPHEROID
ZIN. 11N. 1/21N. NO. NO. NO. NO. NO. NO. NO. NO. NO. N	••	SCREEN ANALYSIS: UPPER LINE, DRY SCREENED (ASTA C136), AFTER WASHING (ASTM C117), LOWER LINE, SCREENED BEFORE DRYING	A=AMGULAR S=SUBAMGULAR R=ROUNDEG P=PLATY C=CUBIC I=IRREGULAR E=ELONGATED SP=SPMEROID
NOSO KO	1.2	INE. SCREE	I=IRREGUL/
NO30	1.5 1.2	LOWER L	C*CUBIC
SCREENS	18.8 31.0 24.1 7.3 4.5 1.1 24.0 28.0 20.0	STH C117).	EB P=PLATY
HT BETWEEN 4 NOS	7.3	WASHING (A	AR R=ROUND
T BY WEIGH	26.0	1) - AFTER	=SUBANGUL
PER CEN	18.8 31.0	IASTA C136	SANGUL AR S
31N. 21N.	4.0	SCREENED (
61N. JIN.	•	NE. DRY	N SCREEN
PCT (+)6 IN-S1ZE	•	UPPER LI	NS BETWEE
MOISTURE PCT(+)6 PCT IN-SIZE	1.5	ANAL YSIS:	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES
MUCK DATA DRY UNIT WT PCF	98	SCREEN	SHAPE

NDEX NDEX 0.20	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 1.0 PCT MOIST	7
FLOW TOUGHESS ANDEX INDEX A.40 0.20	BULK BELK DENSITY PCF AT 0.0 PCT MOIST	000
<u> </u>	APPARENT COHESION PSF AT 1.0 PCT HOIST	170
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT PCT 17.10 15.58 0.90	ANGLE/REPOSE ANGLE/SLIDE APPARENT ANGLE/REPOSE STEEL PLATE COHESION DEGREES AT DEGREES AT PSF AT A.3 PCT MOIST 1.3 PCT MOIST 1.0 PCT HOIST	96
PLASTIC LIMIT PCT 17.10		35
LIMITS PCT 18.00	(-)0.75 IN.SIZE ************************************	36
POT VOL C: ANGE (-)0.056 IN.SIZE 0	(-)0.75 IN.SIZE SPECIF GRAVITY	2.72

72-1 CURRENT: 04/01/73

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STEM	SECONDARY 480	•	THRUST.MAX/OPERATE	хгв 769		BUID! YCE	CURRENT: 04/01/73
POWER SYSTEM	PRIMARY 4160	SHOTCRETE	/OPERATE	CENTER KFTLB KFTLB		MUCKING	72-1 MDN 4
UTILITY LINES	AIR WATE, FUMP 2 IN 4IN	SET.512E.5HAPE	RPM TORQUE.MAX/OPERATE	HEAD.CENTER HEAD 4.5 KFTLB1147 KFTLB	ACING ADVANCE PER HOUR, FT. 5.5	BLASTING	PIPELINE YES*
WATER INFLOW	GPM 5-10	ROOF PLATE 8.2 LB CHANNEL 6 IN X9.5FT OR 13.5 FT AT 2 FT	GES	GAGE 3 ROBBINS DISC 121N W/ESCO RNG	THPUST/SQ FT KERF SPACING FEET KLB 2.99 0.20		BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL WUISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES YES BELT CONV. YES HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE YES* *POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED.
	SIZE HP 36 IN 120	SUPPORT SYSTEM BOLT-TYPE SIZE 6-6FIXS/8 IN	*DIAM*CUTTING EDGES	INTERIOR 43 ROBBINS DISC 12IN• ESCO RING ESCO RING	GUIDANCE THPU LASER KLB	EXPLOSIVES. PONDER FACTOR TOTAL LBS PRIMERS. TRIM INTERIOR CUT	FSIS AFTER MASHIN MITH NATURAL WOI ENIIOMAL RAIL YES HYDRAULIC PIPELI
VENTILATION	CFM PRESS EXHST 18K X	SUPPLY DIESEL TRUCKS JEEPS	CUTTERS.MAKE.TYPE	CENTER IROGEINS DISC 7.5IN TRIPLE W/	POWER SYSTEM 4-200 MP FOR HEAD	ROUND. NO. MOLES DEPTH DIAM. CUI.	DRY SCREEN ANALYSIS SCREEN ANALYSIS CAPABILITY:CONV S BELT CONV. YES LOGY NOT FULLY DE
	GRADE .	PERSONNFL DIESEL TRUCKS JEPS		260	MUCK SYSTEM BUCKETS TO BELT XCAVATION	ROUND. NO. HO DIETH CUI.	IS FOR MDN IS ID BY (N) FOR ISPORT SYSTEM YEHICLES YE ISIBLE TECHNO
TUNNEL	SIZE SMAPE 18 F1 ROUND 1 IN	HAULAGE SY.TEM HUCK 30 IN PIGGYBACK CONVEYOR 36 IN SUSPENDED CONVEYOR	MACHINE EXCAVATION MACHINE	MAKE MODEL ROBBINS 181-122	ANCHOR PRESS MUCK SYS RUCKETS KLB 1000 TO BELT CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES FEED LENGTH	BASI NOTE TRAN FREE

KEY 30A TUNNEL DATA

01550N 2ATIO	9.25 NOTE
YOUNGS PA HOD. R PSIX10E6	
SHORE SCHILDT	36
SHORE	X
#00 FCT EST	65
COMP STRNTH KPSI	
944 PCT Y	121
ROCK PROPERTIES SEDIMENTARY: COMOLOMERATE (BRECCIA) .25 IN TO 10 IN ROUNDED TO ANGULAR BOULDERS	COBPLES. PEBBLES. PRENOMINATELY LINESTONE MATRIX. W/CHERI. SCHIST. DIBASE FRAGMENIS
IDENTIFICATION MSU	HSU-1

KEY 31

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HO2180643-72.

PCT (-) NO286	0 · N
	•
020	1.0
N030	12.0 .24.0 18.0 16.0 4.0 3.0 2.0 1.0 1.0
REENS	2.0
EEN SCR	3.0
HT 8ET	•
BY WEIG IN. NO	16.0
R CENT	18.0
N	24.0
JIN.	
ein. Jin	17.0
PCT(+)6 IN-SIZE	0
MOISTURE PCT	5.6
NUCK DATA DRY UNIT WT PCF	104

SHAPE OF FRACTIONS GETWEEN SCREEN SIZES A MANGULAR SMSUBANGULAR RMROUNDED PMPLATY CHCUBIC IMIRREGULAR FMELONGATED SPMSPHENDIO

NESS.	, N	SIZE(=)2.0 IN. ANGLE INTER FRICTION DEGREES AT 0.3 PCT WOIST	*
TOUR	0.32		
FLOW TOUGHNESS INDEX	3.20	BULK DENSITY PCF AT T 0.0 PCT MOIST	111
•	1.03	APPARENT COMESION PSF AT 0.3 PCT MOIST (410
PLASTIC SHRIMKAGE PLASTICITY LINIT LINIT PCT PCT	10.78	ANGLE/REPOSE ANGLE/SLIDE APPARENT 10 IN DROP STEEL PLATE COMESION DEGREES AT PSF AT 0.4 PCT MOIST 0.4 PCT MOIST 0.3 PCT MOIST	12
	12.77	ANGLE/REPOSE 10 IN DROP DEGREES AT 0.4 PCT MOIST	59
12E LIGUID 921	13,80	(~)0.75 IN.SIZE *	æ
POT VOL CHANGE (-)0.056 IN.SIZE	0	(~)0.75 IN.SIZE Specif Gravity	2.74

04/01/73 CURRENT: MSU-1

	78414 4168	SHOTCRETE	TORQUE.MAX/OPERATE	CENTER KFTLA KFTLB	
UTILITY LINES	AIR WATER PUMP 6 IN 2 IN	SET.S1ZE.SHAPE	TORGUE :	HEAD.CENTER HEAD KFTLB KFTLB	ADVANCE PER HOUROFT.
01 IL	4 è	567.	a q	HEAD	KERF SPACING FEET
MATER INFLOW	GPR	ROOF PLATE 3FT-4FT-5FT 6 PLATES/5FT SPAN	S	6 4 6£	
	SIZE HP 24 IN SO		TTING EDG		GUIDANCE THRUST/SO FT KLB
	SIZE 24 IN	60L1.TY 6 FT X 21 BOLT SPAN	DIAM, CUI	INTEAIOR	GUIDANC
VENTILATION	PRESS EXHST SIZE X 24 IN	Supply RAIL	S.MAKE.TYPE		POWER SYSTEM
VENTI	M W W		CUTTER	CENTER	MOd
	GRADE 0.0	PERSONNEL RAIL		*	MUCK SYSTEM
DATA	SHAPE RECT SYSTEM	25 84 85	MACHINE EXCAVATION MACHINE	MODEL	
KEY 31A TUNNEL DATA TUNNEL	SIZE SMAPE 9 FT RECT 10 FT HAULAGE SYSTEM	MUCK RAIL 44CF ROCKERCAPS 4-61 MOTORS 30 LB RAIL 18 IN GAGE	MACHINE	₹ B-64	ANCHOR PRESS

THRUST . MAX/OPERATE

PRIMARY SECONDARY

POWER SYSTEM

CONVENTIONAL EXCAVATION

EXPLOSIVES. POWDER FACTOR 8.2 LB/CY TOTAL LBS 150 PRIMERS. 25 LB ANGGEL NO.	TRIM CARBANITE INTERIOR CARBANITE CUT CARBANITE LIFTERS CARBANITE
ROUND. NO. HOLES 42-50 DEPTH 5.5 FT	SF/HOLE 2.0
MACHINE JUMBO 3 BOOM MACHINES 31N DIA DRIFTER	FEED LENGTH 7FT

RLASTING MELECTRICAL E. IGNITER CORD 2: NO. 6 CAPS+FUSE

GUIDANCE LASER

BASIS FOR MDW IS DRY SCREEN AMALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
JRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES*
FREE VEHICLES YES BELT CONV. YES HYDRAULIC PIPELINE NO P-NEUMATIC PIPELINE NO *POSSIBLE.TE:MNOLOGY NOT FULLY DEVELOPED.

MSU-1

10ENTIFICATION MSU	ROCK PROPERTIES SEDIMENTARY: CONGLOMERATE 1/4 - 10 IN ROUNDED TO ANGULAR BANK NEDE: CABBERTE.	0 Z 0	COMP STRNTH	9.0	SHORE	HARDNESS	YOUNGS MOD. BSTX 18FA	POISSON RATIO
MSU-2	IN PREDOMINATELY LIMESTONE MATRIX, W/CHERT, SCHIST DIAMASE FRAGMENTS WELL TO MODERATELY CONSOLODATED	691	25	•	ح 2	\$	9.10	. 22

KEY 32 NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UMPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HO210043-72.

PCT (-) 7.0 61N. 31N. ZIN. 11N. 1/ZIN. MO4 NO8 NO16 NO30 NO50 NO180 NO200 0.7 .. 1.5 5.1 28.9 17.2 16.0 10.4 PCT (+)6 IN.S1ZE 19.1 MOISTURE PCT 6: MUCK DATA OPY UNIT 4T PCF 101

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A A ANGULAR SASUBANGULAR RAROUNDED PAPLATY CACUBIC INTREGULAR FAELONGATED SPASPMERDID

	OUGHNESS NOEX	1.40	SIZE(-)2.0 IN. ANGLE INTER FRICTION DECREES AT 0.03 PCT MOIST	43.45
∢	FLOW INDEX	4.50	BULK DENSITY PCF AT 0.0 PCT MOIST	96.15
4		•	APPARENT BE COMESION DE COMESI	190
٠ •	SIZE(-) 0.0° PLAST INDEX PCT	6.01		14
< <	PLASTIC SHRINKAGE PLASTICITY LINIT LIMIT PCT PCT	10.67	SIZE(-)2.0 IN ANGLE/SLIDE ANGLE/SLIDE STEEL PLATE DEGREES AT 0.83 PCT HOIST	33.75
∢ ✓	PLASTIC LINIT PCT	13,99	**************************************	29.75
4	E LIQUID PCT	20.00	E ANGLE/REPOSE 1 IN DRAP DEGREES AT 0.83 PCT HOIST	34.2
	POT VOL CHANGE (-)0.056 IN.SIZE	•	(-)0.75 IN.SIZE . SPECIF 11 GRAVITY D	2,65

04/01/73

CURRENT:

450-2

KET 328 TUNNEL DATA						
TUNNE	VENTILATION		WATER INFLOW	UTILITY LINES	POWER SYSTEM	STER
SIZE SHAPE GRADE 9F1 x RECT 0.0	CFH PRESS EXHST GK X	51 SIZE HP 24 IN 50	GPH NONE	AIR WATER PUMP 6 IN 2 IN	PRIMAPY 4160	SECONDARY 480
HALLAGE SYSTEM		SUPPORT SYSTEM				
MUCK PERSONNEL ALL RAIL ALL ALL BUND 4-6F MOTOR 30LB RAIL 18 IN GAGE	SUPPLY RAIL	BOLT,TYPE SIZE 6 FT X 5/8 IN 21 BOLTS/5 FT 5PAN	ROOF PLATE 3.4 1/2. 6 FT 7 PLATES 1 SPAN	SET+S12E+SHAPE	SHOTCRETE	
MACHINE EXCAVATION						
MACHINE	CUTTERS.MAKE.TYPE.	PE.DIAM.CUTTING EDGES	GES	RPM TORQUE.WA	TORQUE.WAX/OPERATE	THRUST+HAX/OPERATE
MAKE MODEL WT	CENTER	INTERIOR	GAGE	HEAD.CENTER HEAD	CENTER	
				XF11.8 XF11.8	XFTLB XFTLB	KL8 KL8
ANCHOR PRESS MUCK SYSTEM	POWER SYSTEM	GUIDANCE THRU KLB	THRUST/SO FT KERF SPACING FEET KLB	PACING ADVANCE PER HOUR*FT*		
CONVENTIONAL EXCAVATION						
MACHINE JUMBO 2 BOOM NO MACHINES 3IN DIA DE DRIFTER DI FLED LENGTH 6FT SF	ROUND. NO. HOLES 50 DEPTH 5.5 FT DIAM. 1 3/8 IN CUT. V	EXPLOSIVES, POWDER FACTOR 6, TOTAL LBS 122 PRIMERS, ANGEL TRIW INTERIOR ANGEL CUT	TOR 6.7 122 Mogel Mogel or Carbamite	BLASTING ELECTRICAL IGNITER COF FUSE NO. 6	MUCKING EINCO TO 21 CAPS	GUIDANCE Laser Laser
BASIS FOR MDN 1 NOTED BY (N) FC TRANSPORT SYSTE FREE VEHICLES (*POSSIBLE*TEC*N	BASIS FOR MDW IS DRY SCREEN ANALYSIS NOTED BY (N) FOR SCREEN ANALYSIS WITH TRANSPORT SYSTEM CAPABILIT::CONVENTIO FREE VEHICLES (3) BELT CONV. (1) HYDR PPOSSIBLE.TECHNOLOGY NOT FULLY DEVELOT) EXCESSIVE TIPE WEAR PROBABLE.	LYSIS AFTER WASHING UNLESS HITH NATURAL MOISTURE. VENTIONAL RAIL YES SIDE RAID HYDRAULIC PIPELINE NO PUDEYELOPED. (1) EXCESSIVE WES	G UNLESS STURE. SIDE RAIL YES! NE NO PNEUMATIC ESSIVE WIDTH: WE	ESS RAIL YES* PNEUMATIC PIPELINE NO F WIDTH, WEAR, DAWAGE,	2-03#	CURRENT: 04/01/73

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P01550N	0.41
YOUNGS P HOD. PSIX10E6	0.10
HORE SCHITT	Ç
STORE STORE	\$
ROD PCT EST	100
COMP Struth KPSI	2
ORY PCF	161
ROCK PROPERTIES SEDIMENTARY: LIMESTONE LIGHT TO MEDIUM GRAY FINE GRAINED. SOME CHERT MODULES. TRACES TO	OCCASIONAL CLAY PARTINGS
IDENTIFICATION LAWRENCE SAMPLE NO	LAW-2

KEY 33

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

PCT (-) NO288	4.4
6IN. 3IN. 2IN. 11M. 1/2IN. NO. NO. NO.6 NO.5 NO.50 NO.50 NO.60	1.6 0.8
MS	3.0 25.0 18.0 22.1 9.4 6.5 3.5 2.0 1.8
EEN SCREE 108 NO	6.5
MT OETU	4.6
BY WEIG	22.1
ER CENT	18.9
ZIN. 1	25.0
JIN.	3.(
	•
PCT (+) 6 IN-SIZE	0.0
MOISTURE PCT	7.2
MUCK DATA DRY UNIT WT PCF	95

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGAR SESUBANGULAR REROUNDED PEPLATY CECUBIC IMPREGULAR FRELONGATED SPESPHEROID

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PAI

OUGHWESS	S HA P O	8
FLOS INDEX	PCC PCC PCC PCC PCC PCC PCC PCC PCC PCC	13.97
-) 0.1851MPLASTICITY INDEX PCT	APPARENT COMESION PSF AT 7 PCT HOE	0
PLASTIC SHRIMKAGE PLASTICITY FLOW TOUGHNESS LIMIT LIMIT INDEX INDEX PCT PCT A.0.2 4.0 0.05	#A110	ī
PLASTIC LIMIT PCT	2 - 4 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5	88
	MGLE/REPOSE 1N DROP EGREES AT	33
POT VOL CHANGE (-10.065 IN.SIZE	C-)0.75 IN.SIZE ************************************	2.83

04/01/73

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334										
Times.	27.40									
77										
TUNNEL			VENTIL	ILATION			WATER INFLOW	UTILITY LINES	POWER SYSTEM	STEM
							,	1		
3218	SHAPE	GRADE CFM	E L	PRESS EXHST SIZE	SIZE	<u>4</u>	EDX.	AIP WATER PUMP	THE PARTY OF THE P	PRIMARY SECONDARY
13f1	ROUND	+0.25PCT	%	*	281N		21-04	PIN SIN PIN	> 001	>0 1
0 I N										
HAULAGE	HAULAGE SYSTEM				SUPPOR	SUPPOPE SYSTEM				
200						1	1000		FF100+0.0	
#0C#		PERSONNEL		50FFL1		TPE SIZE	BULLITYE SIZE KUUT FLATE	34446 • 17 F 6 • 136	317717	
1		73.65								

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ボス	HODEL WT HARDROCK 400 TONS	CENTER 1 LAWRENCE TCB 24IN TRICONE	INTERIOR GAGE 11 LAWRENCE TCB 5 LAWRENCE TCB 15IN DISC+ 15IN ROLLER	GAGE TCB 5 LAI	MENCE TCB ROLLER	HEAD, CENTER		HEAD CENTER KFTLB	alx
			11-TCB 15IN				KFTLB206	KFTLB	X
ŠŽ	SYSTEM		GUIDANCE LASER	THRUST/SO	GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER Laser Feet Hourist.	ACING AD	VANCE PER HOUR.FT.		
FACE.	FACE . 24 IN CONVEYOR TO REAR	HYDRAULIC 600MP HEAD 150 CENTER		KLB 4.28	0.0		7.7		

CONVENTIONAL EXCAVATION

BLASTING MUCKING		
EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS,	INTERIOR CUI LIFTERS	100 100 100 100 100 100 100 100 100 100
ROUND. NO. HOLES DEPTH DEPTH	• 3	4
MACHINE JUMBO MACHINES	FEED LENGTH	1 : 4 : 1

GUIDANCE

BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES*
FREE VEHICLES YES BELT CONV. YES HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE YES*
*POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED.

LAW-2

POISSON	0.41 NOTE
YOUNGS MOD. PSIXIGE	0.70 WOTE
SWORE SCHIOT	?
SHORE	‡
PCT FCT EST	100
COMP STRNTH KPSI	2
DRY PCF	31
ROCK PROPERTIES SEDIMENTARY: LIMESTONE LIGHT TO MEDIUM GRAY: FINE GRAINED: SOME CHERT MODULES: TRACES TO	
KEY IDENTIFICATION 34 LAWRENCE SAMPLE NO	

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UMPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROMPCSM A.R.HG210043-72.

	~
* PCT (+)	6.6
	1.1
ON 0501	6.3 25.9 19.6 20.2 7.4 5.0 3.5 1.8 1.3 1.1
N DEON	1.8
EENS	3.5
EEN SCR	5.0
HT BETW	7.4
BY WEIGH	20.2
R CENT	19.6
IN. 1	55.9
31N. 2	4.3
61N. 31N.	0.0
PCT (+)6 In-SIZE	0.0
MOISTURE PCI	5.5
MUCK DATA DRY UNIT WI PCF	63

A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR F=ELONGATED SP=SPHEROID FRACTIONS BETWEEN SCREEN SIZES

				r. F	
SILES AMANGULAR SESCONARGULAR RENGANDED TEPTET CECCOLC LERANGULAR FELGRAPHES SELECTIONS		TOUGHNESS	14.0	SIZE(+)2.0 II ANGLE INTER FRICTION DEGREES AT 7 PCT NOIST	ä
1-1vuevol-1	j anj	FLOW	•	BULK BENSITY PCF AT 0.6 PCT MOIST	94.04
1902-2	-		0° N	151	
משטבט ריירני	~	PLASTIC SHRIMKAGE FOR INDEX. SIZE(-) 0.165IN LINIT LINIT PCT PCT	1.2	A C A	J
ממרשע איינס	PAI I	4178SIZE ((AGE		(")2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 8.4 PCT HOIST	38
באטסטאט אאין	14	TERBERG LIN SHRINN LINIT	10.0	ANGLE/REPOSE ANGLE/SLIDE ANGLE/SLIDE 10 IN DROP STEEL PLATE DEGREES AT DEGREES AT 6.1 PCT MOIST 8.4 PCT MOIST	F7
ES ASANO	PAI PAI	PLASTIC LINII PCT	10.6	.MATERIAL LEZREPOSE IN DROP REES AT PCT MOIST	9
SLKEEN SIG	a	LIGUTO LIMITS PCT			·
SHAPE OF FRACTIONS BEINGEN SCHEEN			11.0	ANGLE/REPOSE 1 IN DROP GEGREES AT 6.1 PCT NOIST	Ŧ
OF FRACTIO		POT VOL CHANGE (=)0.065 IN.SIZE		(~)0.75 IN.SIZE ALSPECIF GRAVITY I	
SHAPE		POT VOI	ċ	SPECIF SPECIF GRAVITY	2.R0

84/01/73

04/01/73
CURRENT :
-
LAN-3

STER	SECONDARY ABOV				THRUST.MAX/OPERATE	KLB KLB 614		-		GUIDANCE		CURRENT: 04/01/73
POWER SYSTEM	Primary A160V		SHOTCRETE		K/OPERATE	CENTER KFTLB KFTLB				MUCK ING		LAN-3
UTILITY LINES	AIR WATER PUMP 61N 21N 61N		SET.SIZE.SHAPE		RPH TORQUE + MAX/OPERATE	HEAD.CENTER HEAD 9 30 KFTLB KFTLB206	¥	HOUR + F1 + 7 + 7 + 7	,	BLASTING .		S AIL VES* PNEUMATIC PIPELINE VES*
WATER INFLOW	GP# 40-120		ROOF PLATE		6ES	GAGE 5 LAWRENCE TCB 15IN ROLLER	THRUST/SQ FT KERF SPACING	4.28 0.20		10R		G UNLESS STURE. SIDE RAIL YES* NE NO PNEUMATIC
	SIZE HP 201N	SUPPORT SYSTEM	BOLT.TYPE SIZE NONE		.DIAM.CUTTING EDGES	INTERIOR 11 LAWRENCE TCB 15IN DISC+ 11 TCB 15IN ROLLER	MCE	LASER KLB 4.28		EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS.	INTERIOR CUT LIFTERS	SIS AFTER WASHING UNRESS WITH NATURAL MOISTURE. INTIONAL RAIL YES SIDE RAIL YES* WYDRAULIC PIPELINE NO PNEUNATI
VENTILATION	CFH PRESS EXHST 20K X		SUPPLY PAIL		CUTTERS.HAKE.TYPE	CENTER 1 LAWRENCE TCB 24IN TRICONE	POWER SYSTEM	ELECTRO- HYDRAULIC 600HP NEAD 150 CENTER		ROUND. NO. HOLES DEPTH DIAM.		BASIS FOR MDN IS DRY SCREEN ANALYSIS NOTED BY (N) FOR SCREEN ANALYSIS TRANSPORT SYSTEM CPABLITY:CONVERE VEHICLES YES BELT CONV. YES #POSSIBLE,TECHNOLOGY NOT FULLY DE
	GRADE +0.25PCT	•	PERSONNEL Rail	NTION		MODEL HT HARDRJCK 400 TONS	MUCK SYSTEM	BUCKETS FROM FACE 24IN CONVEYOR TO REAR	EXCAVATION	ROUND NO. W DEPTH DIAM.		ISIS FOR MDN IS OTED BY (N) FOR NANSPORT SYSTEM RE VEHICLES YE POSSIBLE, TECHNO
TUNNEL	SIZE SHAPE 13FT ROUND BIN	HAULAGE SYSTEM	MUCK	MACHINE EXCAVATION	MACHINE	HAKE HAKE HAKE B-70	ANCHOR PRESS	ער 8	CONVENTIONAL EXCAVATION	HACHINE JUMBO MACHINES	FEED LENGTH	8 X 2 4 4 4

34A TUNNEL DATA

KEY

04/01/7	
CURRENT:	
LAW-4	

			PCT (-) Nozoo	ņ	ER010					-
			000	E • •	S S				17. 17.	
POISSON	9.0		NOZOO		NGATED SP		•		SIZE(-)2.0 II Angle inter Priction Degrees at 8.8 pct moist	,
YOUNGS HOD. PSIXIOE6	4.61		0100	% •	AR E=ELO		TOUGHNESS	0.05		
	NOTE	•	BETWEEN SCREENS	8°°	A=ANGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGILAR E=ELONGATED SP=SPHEROID	∢	FLOW		BULK BULK DENSITY O.0 PCT MOIST	
SHORE SCHRIDI	*	CIMEN. 10043-72	N030	en en	C*CUBIC	ď	FLOW	4.7	BULK BULK DENS FCF MOIST 0.0	
ROD PCT EST	0	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.HO210643-72.	CREENS	3.4) Paplaty	¥d	9561N		APPARENT COHESION PSF AT 8-8 PCT MO	
COMP STRNTH KPSI	9	3. UNPOL! FROM CSM	BETWEEN S	7.3 5.1	?=ROUNDED	14	IZE (-) 0. PLAS INDE PCT	0.2	•	
ORY PCF	157		#E 16HT NO4	17.0 7.	ANGULAR F	Id	LASTIC SHRIMKAGE PLASTICITY SASTICITY INIT PLASTICITY INIT PCT	in.	(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 8.9 PCT MOIST	
. •	-	FROM D.U.DEERE AD 646610-66. 5. ASSIGNED MINIMUM VALUE.	PER CENT BY I	18.3	LAR S=SUB	ä	FERBERG L SHRI LINI PCT	13,5	\$12E	
ONE LIGHT GRAINED, TRACES TO		D.U.DEERE	Z	18.3		ī	ASTIC HAT	26.0	ANGLE/REPOSE 10 IN DROP DEGREES AT 8.9 PCT MOIST	
TIES 1 LIMEST RAY FINE NOOULES+ CLAY DADI			61N. 31N. 2	0.0 5.0	EN SIZES	Id	ָב בּיב בּיב פּיב בּיב	Ñ	ANGLE 10 DEGREE 8 9 P	
ROCK PROPERTIES SEDIMENTARY: LIMEST TO MEDIUM GRAY FINE SOME CMERT NODULES.		2. INFERI ILAR ROCI		-	WEEN SCRE		LIGUID LIMITS PCT	20.5	POSE DP AT MOIST	
20 0 C		NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED 4. INFERRED FROM TESTS/SIMILAR ROCK.	E PCT(+)6 IN-S17E	0 • 0	SHAZE OF FRACTIONS BETWEEN SCREEN SIZES		321		ANGLE/REPOSE 1 IN DROP DEGREES AT	
IDENTIFICATION LAWRENCE SAMPLE NO		OF FORM	HOISTURE PCT	7.9	OF FRACT		POT VOL CHANGE (+)0.056 IN.SIZE		1N.SIZE	
		NOTES! 1. 80 PCT.	MUCK DATA DRY UNIT WI PCF	90	SHEZE		POT VOI	•	(+)0.75 SPECIF GRAVITY	
X W S S		MOX	303		,					

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04/01/73	
CURRENT:	
LAW-4	→ NOX

GUIDANCE

NUCK ING

IPELINE YES# WP PROBABLE.
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES YES BELT CONV. (2) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE YES* *POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
TURAL MOISTURE RAIL YES SIDE IC PIPELINE NO (2) EXCESSIV
YSIS WITH NATICONVENTIONAL
R SCREEN ANAL H CAPABILITY: ES BELT CONV.
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES YES BELT CONV. (2) HYDRAULIC PIPELINE NO PNEUMATIC *POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUIL
12 PM NL T

	POWER SYSTEM	PRIMARY SECONDARY 4160V 480V		SHOTCRETE
•	UTILITY LINES	AIR WATER PUMP 6IN 2IN 6IN		SET.SIZE.SHAPE
	WATER INFLOW	GPN 40-120		ROOF PLATE
		S12E HP 291N	SUPPORT SYSTEM	BOLT.TYPE SIZE ROOF PLATE NONE
	VENTILATION	I PRESS EXHST SIZE		SUPPLY
	VEN	GRADE CFM +0.25PCT 21K		PERSONNEL Rail
35A TUNNEL DATA	TUNNEL	SIZE SHAPE 13FT ROUND 8IN	MAULAGE SYSTEM	MUCK RAIL

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OPERATE THRUST.MAX/OPERATE	CENTER KLB KFTLB KLB 540	
TORQUE.MAX/OPERATE	HEAD KFTLB KFTLB206	의 보 보 보 보 보 보 보 보 보 보 보 보 보 보 보 보 보 보 보
Media	HEAD.CENTER HEAD 30 KFTLB KFTLB	SPACING ADVANG ET HOUS
CUTTERS.MAKE.TYPE.DIAM.CUT/ING EDGES	INTERICR GAGE 11 LAWRENCE TCB 5 LAWRENCE 15IN DISC+ 11	GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER LASER KLB 3.76 0.20 6.3
CUTTERS . MAKE . TYP	CENTER 1 LAWRENCE TCB 24IN TRICONE	POVER SYSTEM ELECTRO- Hydraulic 600HP 150 Head
	CK 400	CK SYSTEM CKETS FROM CE. 241N NVEYOR TO AR
INE	MAKE MODEL ALKIPA HAMDROCK	ANCHOR PRESS MUCK SYSTEM BUCKETS FROM KIS FACE, 24 IN CONVEYOR TO REAR
MACHINE	14 B-72	ANC KI B

CONVENTIONAL EXCAVATION

MACHINE JUMBG MACHINES	ROUND. NO. HOLES DEPTH	EXPLOSIVES, POWDER FACTOR	BLAST ING
FEED LENGTH	DIAM. CUT.	PRIMERS. IRIA INTERIOR CUT	
80	IASIS FOR MON IS DRY SCREEN A	BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS	

04/01/73	
CURRENT?	
H11-1	

SCHMIDT HOD. RATIO SCHMIDT HOD. RATIO PSIXIBEG NOTE NOTE 2.0 0.3 7.6 2.0 0.5 7.6 I=IRREGULAR F=ELONGATED SPSPHEROID 6.24 0.24 SIZE(-)2.0 ANT. PERCTION ATT. PEGREES AT	38
ESS YOUNGS CHMIDT PSIXIOEG S9 10.00 NOTE NOTE 2.0 0.5 ETREGULAR F=ELON S1ZEC TOUGHNESS	. &
ESS. SS. NOTE 2.3	
STANTH POT SHORE SCHNIDT KPSI EST SHORE SCHNIDT 36 85 NA S9 NOTE 1.21 SHORE SCHNIDT NOTE NO	
STANTH FGD SHORE STANTH FGT SHORE 36 85 NA 3. UMPOLISHED SPECIMEN. FROM CSM A.R.HOZIO043- PROM CSM A.R.HOZIO043- SETYEEN SCREENS	95
COMP STRNIH KPSI 36 36 36 3. UMPOLI 6. FROM CSM NO6 8.2 6.3 8.2 6.3 PI PA FI PA INDEX FCT INDEX COMP COMP COMP COMP COMP COMP COMP COMP	
DRY WIT PCF 166 646610-66, M VALUE. M VALUE. A VALUE. C E WEIGH Z-1M, NOA Z-	30
FOOT. FOOT. FOOT. FOULAR GULAR ATTERB	
S S S S S S S S S S S S S S S S S S S	35
IDENTIFICATION SEDIMENTARY: LINE FINE GRAINED, HOR SAMPLE NO MIL—1 SAMPLE NO JOINT SPACING 6 II RIL—1 RO PCT. UF FORNATION. 2. INFERRED FRO SO PCT. UF FORNATION. 2. INFERRED FRO INFERRED FROM TESTS/SIMILAR ROCK. 5. K DATA Y UNIT HOISTURE PCT(+)6 ************************************	
	36
SAMPLE NO SAMPLE NO NOTES: 1. 80 PCT. OF FORMATION. 4. INFERED FROM TESTS/S MUCK DATA BRY UNIT HOISTURE PCT WI PCF PCT	
SAMPLE N MIL-1 MIL-1 MIL-1 MUCK DATA BRY UNIT W WUCK DATA BRY UNIT W BSP SSPECIF (-) 0.056	5.89

04/01/73	
CUMPENT	

STEE	SECONDARY A40V				THRUST.HAX/OPERATE	KLB 1104 KLB 596		GUIDANCE	CURRENT: 04/01/73
POWER SYSTEM	PRIMARY 4680V		SHOTCRETE		TORQUE.NAX/OPERATE	CENTER KFTLB KFTLR		WCCK I K	#1L-1 #DN \$
UTILITY LINES	AIR WATER PUMP 61m 11m 61m		SET.SIZE.SHAPE 41N H RING SETS IN FAULT ZONES		RPH TOROUE.NA	HEAD.CENTER HEAD 9.3 INTEG KFTLB 170 KFTLB:	ACING ADVANCE PER HOURSFI + 5-0	BLASTING	IS PREUMATIC PIPELINE YES*
WATER INFLOW	GPM 5.		ROOF PLATE OCCASIONAL PINNEO STEEL LAGGING		GES	GAGE 4 REED STEEL TRIPLE DISC	THRUST/SQ FT KERF SPACING KEB 6.09 0.16	α 0	υ, α.
	SIZE HP 19IN 25	SUPPORT SYSTEM	BOLT.TYPE SIZE		.DIAM.CUTTING EDGES	INTERIOR 22 REED STEEL TRIPLE DISC	GUIDANCE THRUST/S LASER KLB 6.09	EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT	WAAL CARL CARL CARL
VENTILATION	CFN PRESS EXHST		SUPPLY RAIL		CUTTERS+MAKE+TYPE+	CENTER 1 REED STEEL CONE+ 5 DISC	POWER SYSTEM 6-50HP WOTORS FOR HEAD 1-40HP WOTOR HYDRAULIC	ROUND, NG. MOLES DEPTH OIAM. CUT.	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTEINDIED BY (N) FOR SCREEN ANALYSIS WITH NATITRANSPORT SYSTEM CAPABILITY:CONVENTIONAL FREE VEHICLES YES BELT CONV. YES HYDRAULT POSSIBLE, TECHNOLOGY NOT FULLY DEVELOPED.
	GRADE •6.2PCT		PERSONNEL E RAIL	TION		MODEL WI 11-1100 65 10NS	MUCK SYSTEN BICKET FROM FACE. 18IN CONVEYOR TO REAR	ROUND, NO. HO DEPTH OIAM. CUIT.	MASIS FOR MON IS NOTED BY (N) FOR TRANSPORT SYSTEM FREE VEHICLES YES *POSSIBLE**IECHNOL
TUNNEL	SIZE SHAPE	HAULAGE SYSTEM	MUCK RAIL. 24IN GAGE 510N MOTORS	MACHINF EXC.YATION	MACHINE	B-74	ANCHOR PRESS MUCK SYS BLICKET F KLB 1650 FACE 18 CONVEYTONE REAR CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES FEED A.ENGTH	4 ○ ○ ○ ○ ○

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36A TUNNEL DATA

KEY

POISSON RATIO	NOTE
YOUNGS MOD. PSIXIOE6	10.00 NOTE
HORE SCHMIDT	NOTE NOTE
SHORE	ž
ROO PCT EST	5
COMP STRNTH KPSI	36
ORY RT PCF	991
ROCK PROPERTIES SEDIMENTARY: LIMESTONE, GRAY, FINE GRAINED, HORIZONTAL JOINT SPACING 6 IN, TO 1 FOOT,	
IDENTIFICATION MILWAUKEE SAMPLE NO	#1L-2

KEY 37 14 - E-194

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UMPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM 35M A.R.HO210043-72.

PCT (-)	9.
ZIN. 11N. 1/ZIN. NO4 NO8 WO16 NO36 NO50 NO100 NO200 N	7.6
· · · · · · · · · · · · · · · · · · ·	1.2
N030	2.1
REENS	6.4
ETWEEN SC NOS	.5 6.
WEIGHT 8	9.2 24.7 22.8 11.5 6.8 4.9 2.7 1.2 7.6
R CENT BY	24.7
ZIN. 11	9.2
6in. Jin.	0.0 0.0
	•
PCT(+)6 IN.SIZE	0
MOISTURE	6.1
MUCK DATA DRY UNIT	6

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES A=ANGULAR S=SUBANGULAR R*ROUNDED P=PLATY C=CUBIC I=IRREGULAR E=ELGNGATED SP=SPMEROID

	FLOW TOUGHNESS INDEX INDEX 6.10 0.56	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 5.0 PCT MOIST	33
v	× o	BULK DENSITY PCF AT 0.0 PCT MOIST	06
v		BUL DEN PCF	
w	1 ICITY X	APPARENT COMESION PSF AT S.O PCT MOIST 0	110
č	ZE(-) 0. PLAS INDE PCT 3.42	* C Q W	
I d	MITS.SI KAGE	SLIDE SLATE PLATE ES AT	30
a a	ERBERG LIM SHRINK LIMIT PCT 16.37	SIZE(-)24 ANGLE SIEEL DEGRE 5.8 F	
w W	PLASTIC SMRINKAGE PLASTICITY LIMIT LIMIT INDEX PCT PCT PCT 16.68 16.37 3.42	ANGLE/REPIAL SIZE(-)2.0 IN ANGLE/REPOSE ANGLE/SLIDE 19 IN DROP STEEL PLATE DEGREES AT DEGREES AT 5.8 PCT MOIST 5.8 PCT MOIST	30
	E LIGUID LIMITS PCT 20.10	ANGLE/REPOSE ANGLE/REPOSE 1 IN DROP DEGREES AT 5.8 PCT MOIST	32
	POT VOL CHANGE (-)0.056 IN.SIZE 0	(-)0.75 IN.SIZE * SPECIF A GRAVITY D	2.93

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04/01/73

CURRENTS

HIL-2

STEH	SECONDARY 448V				THRUST. HAX/OPERATE	**************************************			GUIDANCE	CURRENT: 04/01/73
POWER SYSTEM	PRIMARY 4680V		SHOTCRETE		X/02ERATE	CENTER KFTLB KFTLB			MUCKING	E III- NOS SI
UTILITY LINES	AIP WATER PUMP 61N 11N 61N		SET.SIZE.SHAPE 4IN H RING SETS IN FAULT ZONES		RPH TORQUE.MAX/OPERATE	HEAD.CENTER HEAD 9.3 INTEG KFTLB 170 KFTLB	KERF SPACING ADVANCE PER FEET HOUR.FT. 0.18		BL.ASTING	PIPELINE YES• Loup Probable.
WATER INFLOW	бри 10		ROOF PLATE OCCASIONAL PINNED STEEL LAGGING		3ES	GAGE 4 REED STEEL TRIPLE DISC	T		&	JUNESS STOR FAIL YEST E YES PNEUMATIC SSIVE FINES BUIL
	SIZE HP 187N 25	SUPPORT SYSTEM	BOLT.TYPE 512E		DIAM+CUTTING EDGES	INTERICA 22 REED STEEL TRIPLE DISC	GUIDANCE THRUST/S LASER NLB 6.09		EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM INTERIOR CUT	IIS AFTER WASHING IITH NATURAL MOIS IITONAL RAIL YES YDRAULIC PIPELIN ELOPED. (2) EXCE
VENTILATION	CFM PRESS EXHST		SUPPLY *AIL		CUTTERS.MAKE.TYPE.	CENTER 1 REED STEEL 2 CONE 5 DISC T	POWER SYSTEM 6-50HP WOTORS FOR HEAD. 1-40HP WOTOR HYDRAULICS		ROUND, NO. HOLES DEPTH DIAM.	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH MATURAL MOISTURE. TRANSPORT SYSTEM CAPABI! ITY:CONVENTIONAL RAIL YES SIDE RAIL VES* FREE VEHICLES YES BELT CONV. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES- *POSSIBLL.TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
	GRADE +0.25PCT		PERSONNEL RAIL	NOI.		ET 655 TONS	MUCK SYSTEM BUCKET FROM FACE. 18IN CONVEYOR TO REAR	CAVATION	ROUMD NO. H DEPTH DIAM.	15 FOR MDN 15 ED BY (N) FOR NSPORT SYSTEM NSPORT SYSTEM E VEHICLES YE SSIBLE + TECHNO
TUNNEL	SIZE SHAPE 11FT ROUND 21N	HAULAGE SYSTEM	MUCK Rail, 24IN GAGE 510N MOTORS	MACHINE EXCAVATION	MACHINE	HAKE HODEL JARVA 11-1100	ANCHOR PRESS KLB 1650	CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES FEED LENGTH	

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KEY 37A TUNNEL DATA

YO''NGS POISSON M RATIO PSIXIBE6	7.84 0.46
HARDNESS	•
SHORE	4
85	2
COMP STANTH KPSI	22
DRY WIT PCF	164
ROCK PROPERTIES SEDIMENTARY: LIMESTONE FINE GRAINED, GREY	
DENTIFICATION MILMAUREE SAMPLE NO	113

¥8 38

		6.N. 3IN. ZIN. 11N. 1/ZIN. NO. NOS NOIG NOSO NOIG NOSO NOESO NOESO NOESO NOESO NOESO	12.6
6 4 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6		**************************************	
PCT SWORE SCHMIDT MC. RATIO PSIXIOE6 81 NA 40 7.84 0.46		NO 166	9.0
SCHIDT 40	•	NOS	9.0
SHORE NA	ECIMEN. 210043-72	*60%	25.4 32.7 17.4 4.3 3.1 2.0 1.2 0.6
	ISMED SPE M A.R.HO	SCREENS.	.1 2.6
STANTH KPS1 22	3. UNFOL	BETHEEN NOS	6.3
56 3	1610-66. 1ALUE. 6	NY WEIGHT	17.4
	RE AD 640 MINIMUM \	ER CENT E IN. 1/21	32.7
	SSIGNED (21M. 1	25.4
• GREY	ED FROM	JIX.	•
FINE GRAINED, GREY	INFERRI		0
	10N. 2. TS/SIMIL	MOISTURE PCT(+)6 PCT IN-SIZE	•
	OF FORMAT FROM TES	401STURE	5.1
SAMPLE NO	NOTES: 1. 60 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 644610-66. 3. UMPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZIBO43-72.	MUCK DATA DRY UNIT	8
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SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AWANGULAR SESUBANGULAR REROUNDED PEPLATY CECUBIC IMPREGULAR EMELONGATED SPREPWERGID

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OHNESS.	0.22	SIZE(-12.0 IN. ANGLE INTER FRICTION DEGREES AT 2.3 PCT MOIST	*
FLOW TOUGHNESS INDEX		BULK DENSITY PCF AT 0.0 PCT MOIST	ν, *
:	3,50	INAPPARENT BUL ATE COMESION DEN NT PSF AT PCF 401ST 2.3 PCT MOIST 0.0	G
PLASTIC SWRINKAGE SIZE(+) 0.056IN PLASTIC SWRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	12.96 0.80	AMGLE/REPOSE ANGLE/SLIDE ANGLE/REPOSE ANGLE/SLIDE 10 IN DROP STEEL PLATE DEGREES AT DEGREES AT 2.5 PCT MOIST	32
	14.40	ANGLE/REPOSE 10 IN DROP DEGREES AT 2.5 PCT MOIST	32
HANGE ******* IN-SIZE LIQUID PCT	15.20	(-)0.75 IN.SIZE ************************************	36
POT VOL CHANGE (~)0.056 IN.SIZE	•	(-)0.75 IN. SPECIF GRAVITY	, , , , , , , , , , , , , , , , , , ,

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CURRENT :	

#01 50 M

RASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES \$10E RAIL YES*
FREE YEMICLES YES BELT CONV. (2) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE YES*
*POSSIBLE·TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.

38A TUNNEL DATA KEY

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TUNNEL			VENT	/ENTILATION				WATER INFLOW	UTILITY LINES	POWER SYSTEM	STEN
SIZE 11FT 2 in	SHAPE	GRADE +0.2PCT	A COM	PRESS EXHST SIZE X 18IN	XHST	SIZE	4 SS	GPH N I NOR	AIR HATER PUND 6IN IIN 6I N	7. INAR	AGBO 440
HAULAGE SYSTEM	SYSTEM					SUPPOR	SUPPORT SYSTEM				
NUCK RAIL 241N GAGE 51 HOTOR	4.1	PERSONNEL RAIL		SUPPLY RAIL		BOL T. T'	BOLT.TYPE SIZE	ROOF PLATE	Set • Size • Shape	SHOTCRETE	

MACHINE EXCAVATION

MACHINE			T5	UTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	DIAM.CUTTI	NG EDGES	X OX		TORQUE . MAX	TORQUE . MAX/OPERATE	TARUST ORAX/OPERATE
B-78	100 11-1	400EL WT	CENTER 1 REED 0K-1		INTERIOR 22 Reed 2K3	GARGE 4 REED PX - S	on We	HEAD.CENTER HEAD	HEAD KFTLB KFTLB119	CENTER CFTLB KFTLB	KLB 639
ANCHOR PRESS		MUCK SYSTEM BUCKETS TO BELT		POWER SYSTEM 6-50MP MOTORS DRIVE HEAD	GUIDANCE LASER	THRUST/SQ FT KLR 6.52	GUIDANCE THRUST/SQ FT KERF SPACING ADVANCE PER LASER KLR 6.52 0.16 4.7	ADVANCE HOUR	FT.		

CONVENTIONAL EXCAVATION

BL ASTING							
EXPLOSIVES.	POWDER FACTOR	TOTAL LBS	PRINCES	TRIM	INTERIOR	5	LIFTERS
ROCKD.	NO. HOLES	DEPTH	DIAM.	cu1.			
MACHINE	JCMB0	MACHINES			FEED LENGTH		

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		PCT (-)		=SPHERO			+	, r	
POISSON RATIO 0.50		**************************************		NGATED SP		•		SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT 3.0 PCT MOIST	ş
YOUNGS MOD. PSIXIEC. 10.63		010	*	AR F*ELC		TOUGHNESS	0.47	и <i>г</i>	
	ě	NO30 NO50 NO160	2.2	A=ANGULAR S=SUBANGULAR R=ROUMDED P=PLATY C=CUBIC I=IRREGULAR F=ELONGATED SP=SPHERGID	∢	FLOW		BULK DENSITY PCF AT 0.0 PCT MOIST	101
SHORE SCHNIDT MA 44	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.HOZ10643-72	NO38	8.0		∢		3.0	•	
# # # # # # # # # # # # # # # # # # #	ISHED SPE	SCREENS	3.7 3.3	PEPLATY	•	LASTIC SHIMKAGE PLASTICITY INIT LIMIT PCT PCT		FESTION POLICY	0,
COMP STRNTH KPS1	FROK CS	BETWEEN S		=ROUNDED	Į	ZE(-) 0.0 PLAST INDEX PCT	1.41	***	
66 PT Y	16-66. UE: 6.	WE TOHY B	21.5 4.3	NGULAR R	•	HITS.SI KAGE	2	E(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 3.1 PCT HOIST	31
	AD 6465	CENT BY M	22.1 2	S=5U 6 A	a.	RBERG LI SHRIN LIMIY PCT	11.57	SIZE(-)2.0 ANGLE/SL STEEL PL DEGREES 3.1 PCT	
hal	U.DEERE GNED HI	•	26.6 2	A=ANGULA	a.	TIC TIC	13.69	IAL	
ES LIGHT LIGHT	FROM D.	31N. 21	3.2	SIZES	a.		13.	ANGLE/REPO 10 IN DROP DEGREES AT 3.1 PCT HO	31
ROCK PROPERTIES SEDIMENTARY: LIMEST FINE GRAINED, LIGHT GREY	INFERREC		6	'N SCREEN		LIGUID LIMITS PCT	15.10	POSE PP AT MOTST	
SEDIM SEDIM FINE O	ION. 2. 15/51HTL/	PCT (+)6 IN.SIZE	•	IS BETWEE			15	GE / RE CAREES PCT	37
AT 10%	FORMATI	MOISTURE PCT	œ į	FRACTION		HANGE In.size			-
IDENTIFICATION MT GREEN SAMPLE NO EVG-1	NOTES: 1. 88 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646510-66. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE.	DATA UNIT PCF	8	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES		POT VOL CHANGE (-)0.056 IN.S		(-)0.75 IN.SIZE SPECIF Gravity	2.81
XEX 39 X X X X X X X X X X X X X X X X X X	NOTES:	M DCK	\$	vi	B-79		•	îva	N

CURRENT: 04/01/73

PUIDANCE

PUCKING

	UTILITY LINES	AIR WATER PUND 3 IN		SET + SIZE + SHAPE
	WATER INFLOW	100 00 0		ROOF PLATE
		S12E HP 301N 90	SUPPORT SYSTEM	BOLT.TYPE SIZE NONE
	VENTILATION	+ PRESS EXHST SIZE X 30IN		SUPPLY RAIL
	VEI	GRADE CFM +0.2PCT 18		PERSONNEL Rail
		SHAPE	SYSTER	2 4 52 4 53 4 1
KEY 39A TUNNEL DATA	TUNNEL	512k 10f1 4 IN	MAULAGE SYSTEM	MUCK RAIL 4CY CARS 5T MOTOR 24IN GAGE 54 LB RAIL

PRIMARY SECONDARY 7200 480

SHOTCRETE

POWER SYSTEM

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MACHINE EXCAVATION

THRUST . MAX/OPERATE	KL8 230	
TORQUE . MAX/OPERATE	CENTER KFTLB KFTLB	
TOROUE.NA	HEAD KFTL8 KFTL8230	CE PER R·fT. 9.2
RPH	HEAD.CENTER 6	ING ADVAN
œ		KERF SPAC: FEET 0.24
G EDGES	GAGE 6 ROBBINS 12 IN DIA 01SC	THRUSI/SO FT KERF SPACING ADVANCE PER FEET HOUR:FT. KLB 2.74 0.24 9.2
E.DIAM.CUTTI	INTERIOR 2 ROBBINS 12 IN DIA DISC	GU I DANCE Laser
CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	CENTER 3 ROBBINS 11 IN DIA DISC	POWER SYSTEM 4-100 MP MOTURS DRIVE MEAD
	41 75 70NS	MUCK SYSTEM BUCKET TO BELT
	MODEL 105-144	
MACHINE	HAKE MOBBINS B-80	ANCHOR PRESS KLB

CONVENTIONAL EXCAVATION

9WI		
BLASTING		7ES+
		BASIS FOR MDN IS DRY SCREEN AMALYSIS AFTER WASHING UNLESS NOTED BY IN) FOR SCREEN AMALYSIS WITH NATURAL WOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES. FREE VEHICLES YES BELT CONV. YES MYDRAULIC PIPELINE NO PNEUMATIC PIPELINE YES. *POSSIBLE:TECHNOLOGY NOT FULLY DEVELOPED.
		S AIL YES• PNEUMATI
FS. ACTOR	-	ING UNLES OISTURE. ES SIDE A LINE NO
EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS.	INTERIOR CUT	FTER WASH NATURAL M AL RAIL Y ULIC PIPE ED.
		HALYSIS A SIS WITH ONVENTION YES HYDRA Y DEVELOP
ES		ASIS FOR MDN IS DRY SCREEN AMALYSIS AFTE HOTED BY IN) FOR SCREEN AMALYSIS WITH NAT PANSPORT SYSTEM CAPABILITY:CONVENTIONAL REE VEHICLES YES BELT CONV. YES HYDRAUL! POSSIBLE:TECHNOLOGY NOT FULLY DEVELOPED.
ROUND. NO. HOLES DEPTH DIAM.		FOR SCRISTEN CAPISTEN CAPISTEN CAPISTEN CAPISTEN CAPISTEN CAPISTEN CAPISTEN CAPISTEN CAPISTEN CONTROLOGY
		IS FOR MEDICAL STATES OF THE S
E S	ENGTH	BAA TRA FRE
MACHINE JUMBO MACHINES	FEED LENGTH	

P01550N RATTO	0:30
Youngs Hod. Psix10e6	10.82
HARDNESS	45
SHORE	4
800 PCT	100
COMP STRNTH KPS1	30
ORY CT	170
ROCK PROPERTIES SEDTWENTART: LIMESTONE FINE GRAINED. LIGHT GREY	
40 MT GREEN SAMPLE NO	5-0-C
KE ¥	

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZIO043-72.

5.9 4.0 2.3 3.0 3.0 4.0 17.8 24.4 26.7 2.2 0.0 PCT(+)6 IN-S17E 0.0 MOISTURE PCT 2.5 MUCK DATA ORY UNIT WT PCF 3

SHAPE OF FRAL. IONS BETWEEN SCREEN SIZES A=ANGULAR S*SUBANGULAR R=ROUNDED P=PLATY C*CUBIC I=IRREGULAR E=ELONGATED SP~SPMEROID

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TOUGHNESS TNDEX	00°	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 3.15 PCT MOIST	36.1
FLOW TOUGHNESS INDEX	2.70	BULK BULK DENSITY PCF AT 3.15 PCT MOIST	91.18
-) 0.056IN PLASTICITY INDEX PCT	2.70	INAPPARENT BULK SE COMESION DENSITY I PSF AT PCF AT 3.15 PCT MOIST 3.15 PCT MOIST	410
PLASTIC SHRIMKAGE PLASTICITY LIMIT LIMIT PCT PCT	12,06	IIZE(-12.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 3.15 PCT MOIST	31.92
PLASTIC LIMIT PCT	12.80	ANGLE/REPOSE ANGLE/SLIDE 10 IN DROP STEEL PLATE DEGREES AT DEGREES AT 3.15 PCT MOIST 3.15 PCT MOIS	34.4
LIQUID LIMITS PCT	15.50	NGLEZREPOSE IN DRAP EGREES AT 15 PCT MOIST	40.1
POT VOL CHANGE (-)0.056 IN.SIZE	0	(-)0.75 IN.SIZE *SPECIF SPECIF GRAVITY 1 IN DROP DECREES AT 3.15 PCT MOIST	2,473

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04/01/73	
CURRENT:	
EVG-2	

GUIDANCE

NUCK ING

BLASTING

	STER	SECONDARY 480				THRUST . MAX/OPERATE	492 WIR	
	POWER SYSTEM	721848 7200 7200		SHOTCRETE		(/OPERATE	CENTER KFTLB KFTLB	
	UTILITY LINES	AIR HATER PURP 31h		SET.SIZE.SHAPE		RPH TOROUE.MAX/OPERATE	HEAD.CENTER HEAD 6 KFTLB246	KERF SPACING ADVANCE PER FEET HOURSFT. 0.24 11.5
	WATER INFLOW	# 00 4	1 3	ZE ROOF PLATE		EDGES	GAGE 2 ROBBINS 12 IN DIA DISC	TMRUSI/SQ FT KERF SPI KLB 3.18 0.24
		SIZE MP 30 IN 90	SUPPORT SYSTEM	BOLT.TYPE SIZE NONE		*DIAM CUTTING	INTERIOR 21 ROBRINS 12 IN DIA DISC	GUIDANCE T LASER K
	VENTILATION	CF3 PRESS EXHST 18 X		SUPPLY RAIL		CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	CENTER 3 ROBBINS 11 IN DIA DISC	POWER SYSTEM 4-100 HP MOTORS DRIVE HEAD
		GRADE • 0 • 2PCT		PERSONNEL RAIL	*6		44 75 10NS	MUCK SYSTEM BUCKET TO BELT
40A TUNNEL DATA	TUNNEL	SIZE SHAPE 10 FT ROUND 4 IN	HAULAGE SYSTEM	MUCK RAIL 4CY CARS 51 MOTOR 24 IN GAGE 54 LB RAIL	MACHINE EXCAVATION	HACHINE	MAKE MODEL POBBINS 105-144	ANCHOR PRESS W RLB
							B-82	

KEY

EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS.	TRIM INTERIOR CUT LIFTERS
ROUMD. NO. HOLES DEPTH DIAM.	• 103
MACHINE JUMBO NACHINES	FEED LENGTH

z	
POISSON RATIO	**10 NOTE
YOUNGS MOD. PSIXIOE6	1.80 NOTE
HORE SCHAIDT	2
SHORE	¥ 2
800 851	*
COMP STRNTH KPSI	90
94 4 C4 4	150
ROCK PROPERTIES SEDIMENTARY: SANDSTONE MEDIUM GRAIMED. LIGHT BROWN TO RED. MASSIVE. POROUS. POORLY	CEMENTFD.
IDENTIFICATION LAYOUT	LAY-1

KEY 4

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NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HO210043-72.

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PCT (-)	72.2
21N. 11N. 1/21N. NO4 NOB NOIG NO30 NOSO NOIGO NOSO	0.
980	5.7 12.0 12.6 4.6 3.4 2.7 1.8 15.4 1.0
000	7.9
EENS	2.1
WEEN SCR NOS N	9.6
347 BET	4
BY WEIG	12.6
ER CENT IN. 1/2	12.0
IN.	5.7
31%	F.
514. 31N.	7.6
PCT(+)6 .N.SIZE	0.0
MOISTURE PCI	;
NUCK DATA DRY UNIT WI PCF	105

SHAPE OF FRACTIONS BETWIEW SCREEN SIZES AMANGAR SESUBANGULAR REROUNDED PAPLATY CHOURIC INTRREGULAR FILLONGATED SPASPHEROID

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OUGHANESS	25.0	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 3.6 PCT MOIST	•
FLOW TOUGHNESS INDEX	6.00	BULK DENSITY PCF AT MOIST 0.0 PCT MOIST	4.70
-) 0.056IN PLASTICITY INDEX PCT	3.14	APPARENT COMESION PSF AT 3.6 PCT MOIST (210
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	15.17	ANGLE/REPOSE ANGLE/SLIDE APPARENT OF IN DROP STEEL PLATE COMESION DEGREES AT DEGREES AT PSF AT 3.6 PCT MOIST 3.6 PCT MOIST	23
PLASTIC LIMIT PCT	17.06		æ
SIZE LIQUID LIMITS PCT	21.20	(-)0.75 IN.SIZE *	33
POT VOL CHANGE (-)0.056 IM.SIZE	0	(-)0.75 IN.SIZ SPECIF GRAVITY	2.66

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GUIDANCE

NUCK THE

	/STEH	PRIMARY SECONDARY 7306V 466V		
	POWER SYSTEM	>441140 >4000 +		SHOTCRETE
	UTILITY LINES	AIR MATER PUNP 6IN 3.5IN BIN		SET.SIZE.SHAPE Ain H Rimgs at Aft
	WATER INFLOW	66 H		ROOF PLATE 131N X 9FT
		SIZE HP 36IN 100	SUPPORT SYSTEM	80LT.TYPE SIZE 3/4IN X 7FT. 10PCT
	ILATION	PRESS EXHST		SUPPLY Rail
	VENTILA	GRADE CFM +0.125PCT15K		PERSONNEL RAIL
41A TUNNEL DATA	VE.	SHAPE T ROUND	HAULAGE SYSTEM	MUCK RAIL, Z4IN GAGE 65LB RAIL, 1070N MOTORS 10 CY CARS
12	TUNNEL	S12E 12FT 111N	HAU	RAII 10101

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	MACHINE			CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	E.DIAM.CUTTIN	<u>چ</u>	S. S.
B ~	MAKE ROBBINS	MODEL 141-127-1	#1 125 TONS	CENTER 1 ROBBINS 11IN STEEL TRIPLE DISC	INTERIOR 23 ROBBINS 1 STEEL DISC	II II	GAGE 6 ROBBI STEEL C

MACHINE EXCAVATION

THRUST . MAX/OPERATE

TORQUE . MAX / CPERAYE

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KLB 900 KLB 357AV

CENTER KFTL® KFTL®	
HEAD.CENTER HEAD 5.2 INTEG KFTLB NA KFTLB498AV	ADVANCE PER Hour.ft. 20.0
	CERF SPACING FEET 0.21
GAGE N 6 ROBBINS 121N STEEL DISC	THRUST/SQ FT KERF SPACING FEET FEET 6.21
INTERIOR 23 ROBBINS 111N STEEL DISC	GU I DANCE LASER
CENTER 1 ROBBINS 11IN STEEL TRIPLE DISC	POWER SYSTEN 6-100HP MOTORS FOR HEAD
MODEL 141-127-1 125 TONS	MUCK SYSTEM BUCKETS FROM FACE, 36IN CONVEYOR TO REAR
HAKE HOBBINS 141-	ANCHOR PRESS KLB 1000

CONVENTIONAL EXCAVATION

BLASTING	NO BLE•
EXPLOSIVES. POWDER FACTOR TOTAL LBS PRIMERS. TRIM INTERIOR CUT	BASIS FOR MDW IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL HOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES* FREE VEHICLES YES BELT CONV. (2) HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO *POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
ROUND. NO. HOLES DEPTH DIAM. CUT.	BASIS FOR MDN IS DRY SCREEN AND NOTED BY (N) FOR SCREEN AND TRANSPORT SYSTEM CAPABILITY: FREE VEHICLES YES BELT CONV. *POSSIBLE, TECHNOLOGY NOT FULL
MACHINE JUMBO MACHINES FEED LENGTH	

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CURRENTS	
-AV-2	

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			PCT '(-) NO240	12°3					TER IN.
P01550N RATIO	o. 10 att		NO200	_	ONGATED S		* * * *		Size(-)2.0 Angle inter Friction Degrees At 3.0 PCT MOIS
YOUNGS MOD. PSIXIOE6	16.80 NOTE		NO 100	A. 4	A.AR E=EL		TOUGHNESS	0.21	
SHORE SCHNIDT	WTD AV.	.54	SCREENS NO30 NO50 NO100 NO200	2.0 4.0	R#ROUNDED P#PLATY C#CUBIC I*IRREGULAR E*ELONGATED SP#SPNEROID	<	FLOW	•••	BULK DENSITY PCF AT 0.0 PCT MOIST
SHORE	*	PECIMEN. 0210043-1	NON	0.4	17 C#CUB	∢			40157
929	92	3. UNPOLISHED SPECIMEN. FROM CSW A.R.HO210043-	SCREENS NO 16	4 0.3	€0 P#PL\$	٠ •	0.056IN. ASYICITY IDEX	2	APPA COHE PSF
COMP STRNTH KPSI	WTD AV	3. UNPOLISHED SPECIMEN. 6. FROM CSM A.R.HO216043-72	BETWEEN NOB	0	R R=ROUND	<	SIZE(-) IN IN	0.82	IN. 10E ATE AT MOIST
087 84 904	153	646618-66. NA VALUE. 6	ZIN. 11N. 1/21N. NOS	.0 23.0	A=ANGJLAR S=SUBANGULAR	∢	BERG LIMITS. SHRINKAGE LIHIT PCT	13.60	SIZE(-)2.0 ANGLE/SLIDE STEEL PLATE DEGREES AT 3.4 PCT NOI
ES CONGLOMERATE OBBLES TO ARTZITE	ED MITH SAMOSTONE	D FROM D.U.JEERE AD 646610-66. 5. ASSIGNED MINIMUM VALUE.	6in. 3in. 2in. 1in.	0.06 0.0		a.	**************************************	14.18	MATERIAL JGLE/REPOSE JIN DROP EGREES AT
ROCK PROPERTIES SEDIMENTARY: CONGLOM WELL GRADED COBBLES PERRIES OF QUARTZITE	POORLY CEMENTED WITH REDDISH BROWN SANDST	NOTE3: 1. 80 PCT, OF FORMATIOM. 2. INFERRED FROM 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. A:	PCT(+)6 * IN.SIZE 6IN.	•	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES		LIOUID LIMITS PCT	15.00	A GLEKEPOSE A 1 1N DROP DEGNEES AT DO
ICATION	:	OF FORMATION FROM TESTS/	MOISTURE PC PCT IN	3,3 0	OF FRACTIONS		РОТ VOL СИА NGE (=)0.056 ZN·51ZE		IN.SIZE
	LAY-2	NOTES: 1. BG PCT. 4. INFERRE	HUCK DATA DRY UNIT HT PCF	104	SHAPE		POT V0	ø	5-10.75 SPECIF GRAVITY

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LAY-2 HON 5

GUIDANCE

STER	PRIMARY SECONDARY 7300 480				THRUST . MAX/CPERATE	KLB KLB 585	
POWER SYSTEM	PRIMARY 7300		SHOTCRETE		(/OPERATE	CENTER KFTLB KFTLB	
UTILITY LINES	WATER PUMP 3.5IN 8IN		SET.SIZE.SHAPE 4 IN H FULL RINGS IN BAD GROUND		TORQUE+MAX/OPERATE	HEAD.CENTER HEAD 5.2 KFTLB KFTLB491	MOVANCE PER HOUR.FT. 10.6
	AIA 618		SET. BING GROOM		a a	H A S	KERF SPACING FEET 0.21
WATER INFLOW	6PM 20-10C	x	E ROOF PLATE		EDGES	GAGE 6 ROBBINS 12 IN DIA DISC	THRUST/SQ FT KE
	SIZE HP 36IN 130	SUPPORT SYSTEM	BOLT.TYPE 517E		*DIAM CUTTING EDGES	INTERIOR 23 ROBBINS 11 IN DIA DISC	GUIDANCE LASER
VENTILATION	M PRESS EXHST		SUPPLY RAIL		CUTTERS.MAKE.TYPE.	CENTER 1 1 ROBBINS 2 1) IN TRIPLE 1 DISC D	POWER SYSTEM 6-100 HP MOTORS DRIVE HEAD
νĒΙ	GRADE CFM •0.125PCT15K		PERSOMNEL RAIL	NO I	ເກ	MODEL WT CEN 141-127-1 125 1 F TON 111	MUCK SYSTEM BUCKETS TO BELT
TUNNEL	SILE SHAPE 12 FT ROUND 11 IN	FAULAGE SYSTEM	HUCK FAIL 10 CY CARS 101 MOTOR 24 IN GAGE 65 LB RAIL	MACHINE EXCAVATION	MACHINE	MAKE Odbins	ANCHOR PRESS N
<u> </u>	فسو (۱)	Ĭ.	I G MAN O	Ĭ	Ž	³ B−86	- •

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42A TUNNEL DATA

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CONVENTIONAL EXCAVATION

ROUMD. NO. HOLES	OEPTH DIAM.		BASIS FOR MON IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
MACHINE	MACHINES	FEED LENGTH	BASIS

NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES.
FREE VEHICLES (4) BELT CONV. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES.
FOSSIBLE,TECHMOLOGY MOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
(4) EXCESSIVE ROADBED MAINTENANCE PROBABLE.

POISSON RATIO		9.10	NOTE	•
YOUNGS	PSIXIDE6	00.9	NOTE	J-2
SHORE SCHNIDT		80	#10	AV.
SHORE		¥ Z		
80 FCT		9		
STRNT	To Ak	88	1 0	, ×
SE C	į	165		
ROCK PROPERTIES SEDIMENTARY, CONGLOMERATE 80 PCT QUARTZITE PEBBLES	THAN 12 IN. DIAMETER	TO 30 IN. 20PCT CALCAR-	EOUSLY CEMENTED SAND-	STONE MATRIX.
KEY IDENTIFICATION 52 CNT	CNT-1			

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.P.HO210043-72.

PCT (-)	17.9	92
**************************************	74. 14.	PEENED (ASTM C136). AFTER WASHING (ASTM C117). LOWER LINE. SCREENED BEFORE DRYING
NO1100	10.0	SCREENED
NO50	4.0	ER LINE.
003 003	7.0 4.0). LOWE
SCREENS NOTE	9.0	STM C117
BETWEEN NOS	10.0	SHING (A
Y WEIGHT N. NO4	25.0	AFTER WA
R CENT 8	15.0	C136) •
N. 11	0.0	(ASTR
N. SI		REENED
IN.	••	DRY SC
		LINE.
PCT(+)6 IN.SI7E	90	UPPER
MOISTURE PCT	7.0	CREEN ANALYSIS: UPPER LINE, DRY SCRI
MUCK DATA DRY UNIT WI POF	96	SCREEN

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGULAR SESUBANGULAR REROUNDED PEPLATY CECUBIC IMIRREGULAR FRELONGATED SPESPHEROID

S-A1
S-AI
AI-S
AI S
A1-R
AP-R
PE-R
PE-R

DGHNESS	9.36	SIZE(~)2.0 IN. ANGLE INTER FRICTION DEGREES AT 6.57 PCT MOIST	96
FLOW TO INDEX IN	3.1	BULK DENSITY PCF AT I 0.0 PCT MOIST	113
0.056IN	1.1	INAPPARENT TE COMESION T PSF AT OIST 6.57 PCT HOIST	•
PLASTIC SHRIMKAGE PLASTICITY FLOW TOUGHNESS LIMIT LIMIT INDEX INDEX PCT	15.66	SIZE(")2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 6.57 PCT MOIST	31.67
PLASTIC LIMIT PCT	16.89	ANGLE/REPOSE ANGLE/SLIDE 10 IN DROP STEEL PLATE DEGREES AT DEGREES AT 6.57 PCT WOIST 6.57 PCT MOIST	34.55
LIGUID LIMITS PCT	18.0	(-)0.75 IN.SIZE ************************************	39.65
POT VOL CHANGE (-)0.056 IN.SIZE	Φ	(-)0.75 IN.SIZE SPECIF GRAVITY	2.721

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	STER	SECONDARY 480				THRUST. WAX/OPERATE	KLB 585 KLB 585	
	POWER SYSTEM	PRIMARY 7300		SHOTCRETE		X/OPERATE	CENTER KF1LA KF7LA 515	
	UTILITY LINES	AIR WATER PUMP 6IN 3.5IN 8IN		SFT.SIZE.SHAPE		RPW TORGUE.WAX/OPERATE	MEAD.CENTER HEAD 5.2 KFTLB KFTLB 515	ING ADVANCE PER HOUR•FT• 8.8
	WATER INFLOW U	6РМ 20-200 6		ROOF PLATE 131M X 9FT			GAGE 6 ROBBINS 12 IN DIA DISC	THRUSI/SG FT KERF SPACING FEET KLB 4.47 0.21
		36IN 100	SUPPORT SYSTEM	40LT+TYPE S1ZE 3/4 IN A 7FT		.DIAM.CUTTING E	INTERIOR 23 ROBSINS 11 IN DIA DISC	GUIDANCE THR S LASER KLB
	VENTILATION	FM PRESS EXHST		SUPPLY RAIL		CUTTERS, MAKE, TYPE, DIAM, CUTTING EDGES	CENTER 1 RORBINS 111N TRIPLE DISC	POWER SYSTEM GUIDANCE 6-100 HP MOTORS LASER ORIVE HEAD
	,	GRADE CFM +0.125PCT15K		PERSONNEL Rail	NOIL	C	MODEL WT C	MUCK SYSTEM BUCKETS TO BELT
52A TUNNEL DATA	TUNNEL	SIZE SHAPE IZ FT ROUND II IN	HAULAGE SYSTEM	MUCK RAIL 10 CY CAPS 10 M GAGE 24 IN GAGE 65 LB RAIL	MACHINE EXCAVATION	MACHINE	MAKE HOBBINS 141:	ANCHOR PRESS

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CONVENTIONAL EXCAVATION

MUCK ING
BLAST ING
FXPLOSIVES, POWDER FACTOR POIAL LBS PRIMERS, TRIM INTERIOR CUT
ROUND. NO. HOLES DEPTH DIAM. CUT.
MACHINE JUMBO MACHINES FEEU LENGTH

GUIDANCE

CURRENT: 04/01/73

CNT-1

The same investment

POISSON RATTO	No.10
YOUNGS MOD. PSIXIDE6	0.20 NOTE
SHORE SCHHIDT	NOTE
SHORE	¥
A00 PCT EST	10
COMP STRNTH KPSI	N.
ORY PCF	142
ROCK PROPERTIES SEDIMENTARY: SILTSTONE, FINE GRAINED, GRAY, HORE THAN 33 PCT QUARTZ, 30 PCT CLAY, 10	PCT FELDSPAR. 15 PCT MICA. CHLORITE AND GYPSUM.
IDENTIFICATION NAVAJO SAMPLE NO	NAV-1
Æ €3	

NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

PCT (-) NO200 44.5	PESPHERO!
K DATA MOISTURE PCT(+)6	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGULAR SESUBANGULAR PAROUNDED PAPLATY CHOUBIC IMIRREGULAR FAELONGATED SPASPHEROID
NO30 2-1	S=CV813
CREENS	P=PLATY
BETWEEN S NOB).6 1.	REMOUNDED
BY WEIGHT IN. MOS. 2.2 (After Was	JBANGUL AR
SER CENT (IIN. 1/2) 5.9) 19.0	HALAR S#SL
6.9 23.4 ED (AST	A=ANG
6IN. 3IN. 5 12.1 7.4 19.1 6.8	EEN SIZES
TZE 6IN	TWEEN SCR
10.00 10.00	ONS BET
MOISTURE PCT(+)6 PCT IN-SIZE 8.1 0.0 ANALYSIS: UPPER LI	OF FRACTIC
MUCK DATA DRY UNIT WI PCF R6 SCREEN	SHAPE

•	
TOUGHNESS	1.18
FLON	7.00
IZE(-) 0.056IN. PLASTICITY INDEX PCT	13.19
DO PLASTIC SHRINKAGE PLASTICITY FLOW TOUGHNESS INDEX INDEX INDEX PCT	21.04
PLASTIC LIMIT PCI	23.61
LIGUID LIMITS PCT	36.80
POT VOL CHANGE (-)0.056 IN.SIZE	1,3

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SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 7.5 PCT MOIST	*
BULK BULK DENSITY PCF AT 0.0 PCT MOIST	*
APPARENT COMESION PSF AT 7.5 PCT MOIST	340
SIZE(-)2.0 IN	90
ANGLE/REPOSE ANGLE/REPOSE 10 IN DROP DEGREES AT 7.7 PCT MOIST	90
(-)0.75 IN.SIZE *	æ
(-)0.75 IN.5 SPECIF GRAVITY	3,13

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NAV-1 CURRENT: 04/01/73

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•		POWER SYSTEM	PRIMARY SECONDARY 4160V 440V		SHOTCRETE TO PREVENT AIR SLACKING	TABUST - MAX/OPERATE		CENTER KFR 1503 KFTLB KFTLB KFTLB			MUCK ING GUIDANCE	MAV-1 CURRENT: 04/01/73
		UTILITY LINES	AIR MATER PUMP 61N 41N		SET.SIZE.SHAPE		RPH LORGOL + HAN	MEAD.CENTER MEAD 5 INTEG KF:L8 879 KFTL13 586	KERF SPACING ADVANCE PER FEET HOUR-FT. 0.30		BLASTING	IC PIPELINE NO UILDUP PROBABLE.
		WATER INFLOW	SIZE HP GPM 30IN 60 I	SUPPORT SYSTEM	HOLT.TYPE SIZE ROOF PLATE 3/4IN X BFT OR 5FT OR 13FT 10FT SET IN 16 GAGE EPOXY		CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES	INTERIOR GAGE 30 DRESSER 6 DRESSER SIECL DISC. 26 TC DISCS KENNAMETAL TCB PICK BITS	GUIDANCE THRUST/SO FT LASER KLB 1.31		EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, INTR INTERIOR CUT	SIS AFTER WASHING UNLESS WITH NATURAL MOISTURE. INTONAL RAIL YES. HYDRAULIC PIPELINE NO PNEUMATIC PIPELINE NO EVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
		VENTILATION	GRADE +0.05PCT	7	PERSONNEL SUPPLY GE RAIL RS		CUTTERS, MAKE, TYPE	MODEL WI CENTER TB-205 200 4IN CHISEL TONS KENNAMETAL TC PICK BITS	AUCK SYSTEM POWER SYSTEM QUCKETS FROM 4-160MP DC FACE. 361N MOTORS FOR HEAD CONVEYOR TO 1-75MP MOTOR. REAR	EXCAVATION	ROUMD. NO. HOLES DEPTH DIAM. CUT.	BASIS FOR MON IS DRY SCREEN ANALYSIS AFTE NOTED BY (N) FOR SCREEN ANALYSIS WITH NAT TRANSPORT SYSTEM CAPABILITY.CONVENTIONAL FREE VEHICLES (4) BELT CONV. (2) HYDRAUI. *POSSIBLE,TECHNOLOGY NOT FULLY DEVELOPED.
K E Y	43A TUNNEL DATA	1 NASE	S12E SHAPE 20FT ROUND 61N	HAULAGE SYSTEM	HUCK HAIL. Z4IN GAGE 70LU. 16CY CARS 15ION MOTOR	MACHINE EXCAVATION	MACHINE	B- 90	ANCMOP PRESS	CONVENTIONAL	MACHINE JUMBO MACHINES FEED LENGTH	W & F % F

POISSON RATIO	NOTE
YOUNGS MOD. PSIXIOE	MO1E
**************************************	NOT E
SHORE	4
7 P P P P P P P P P P P P P P P P P P P	•
COMP STRNTH KPSI	LESS THAN
9 K 0	111
ROCK PROPERTIES SEDIMENTARY: SANDSTONE GRAY HEDIUM GRAINED, HASSIVE, FRIABLE AND PORDUS, GRAINS ANGULAR TO SUBROUNDED,	PRIMARILY QUARTZ, POORLY CEMENTED,
IDENTIFICATION NAVAJO SAMPLE NO NAV-2	
¥4 74	

No.

. 3. UMPGLISHED SPECIMEN. 6. FROM CSM A.R.H0210043-72. NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. (

PCT (-) 29.1 SCRZEN ANALYSIS: UPPER LINE. DRY SCREENED (ASTM C136). AFTER WASHING (ASTM C117). LOWER LINE. SCREENED BEFORE DRYING 61N. 31M. 21N. 11N. 1/21N. NO4 NOS NO16 NO30 NOSO NO190 NO200 : 10.0 12.7 11.4 23.2 2.3 2.5 0.0 1.3 12.6 19.6 ••• PCT(+)6 IN-S17E • • MOISTURE PCT 8.2 MUCK DATA DRY UNIT NT PCF 87

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SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AFANGULAR SFSUBANGULAR REROUNDED PEPLATY CECUBIC INTREGULAR FEELONGATED SPESPWEROID

TOUGHNESS TOUGHNESS GOOD TO GHNESS GOOD TO GHNESS GOOD TO TOUGHNESS GOOD TO TOUGHNESS GOOD TOUGHNES	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT 8.1 PCT MOIST	2
FLOW TOUGHNESS INDEX INDEX 4.50 0.28	BULK DENSITY PCF AT 0.0 PCT HOIST	:
I I	IN APPARENT BULK COMESION DENSITY PSF AT PCF AT ST 8.1 PCT NOIST 0.0 PCT MOIST	SO 4
PLASTIC SMRIMKAGE PLASTICITY LIMIT LIMIT INDEX PCT PCT 16.91 16.90	10E AT AT HOI	24
PLASTIC LIMIT PCT 16.91	AMSLE/REPOSE ANGLE/SI 10 IN DROP STEEL PL DEGREES AT DEGREES 8.6 PCT MOIST 8.6 PCT	58
Liguid Liguid Limits PC1 18.20	SPECIF ANGLE/REPOSE GRAVITY I IN DROP DEGREES AT 8.6 PCT MOIST	ï
POT VOL CHANGE (-)0.056 IN.SIZE 0	(-)0.75 IN SPECIF GRAVITY	2.72

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NAV-	Ş

	STEM	PRIMARY SECONDARY 4160V 440V		-
	POWER SYSTEM	PR11484 4160<		SHOTCRETE TO PREVENT AIR SLACKING
	UTILITY LINES	AIR WATER PUNP 61N 41N		SET+SIZE+SHANE
	WATER THFLOW	₽ P P		ROOF PLATE SFT OR 13FT 16 GAGE
		S12E HP 301N 60	SUPPORT SYSTEM	BOLT, TYPE SIZE ROOF PLATE 3/4IN X 8FT ON SFT OR 13FT 10FT SET IN 16 GAGE EPOXY
	VENTILATION	PRESS EXHST SIZE X 301N		SUPPLY
	VENT	GRADE CFM +0.05PCT 18K		PERSONNEL Rail
44A TUNNEL DATA	TUNNEL	SIZE SHAPE 20FT ROUND bin	HAULAGE SYSTEM	MUCK RAIL. 24IN GAGE 70LB RAIL. 16 CY CARS 15TON MOTOR
				_

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KEY

MACHINE EXCAVATION

MACHINE MAKF MODEL		CUTTERS.MAKE.TYPE	DIAM.CUTTIN	IG EDGES GAGF		CFLTER.	TORQUE.MAX/OPERATE HFAD CFN	OPERATE	Thrust • max/oderate
18-205	05 200 TONS	4IN CHISEL 6 KENNAMETAL TC PICK BITS	30 DRESSER STEEL DISC. 26 KENNAMETAL TC PICK BITS	6 DRESSER TC DISC		S INTEG KFTLL	KFTL8 879 KFTL8 586	KF7LB KF7LB	KLB 1583 KLB 123
583	HUCK SYSTE! UCKETS FROM	•	GUIDANCE LASER	THRUST/50 FT	GUIDANCE THRUSI/SQ FT KERF SPACING ADVANCE PER LASER FEET HOUR,FT.	ADVANCE HOUR.	PER F1.		
KLB 616 R	FACE. 36IN CONVEYOR TO REAR	MOTORS FOR HEAD 0 1-75MP MOTOR. HYDRAULICS	0	KLB 0.37	0.3 0	•	ហ		

CONVENTIONAL EXCAVATION

GUIDANCE

BASIS FOR MDN IS DAT SCREEN ANALYSIS AFIER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS MITH NATURAL HOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES.
FREF VEHICLES (4) BELT CONV. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES PREUMATIC PIPELINE PESSIBLE,TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
(4) EXCESSIVE ROADBED MAINTENANCE PROBABLE.

IDENTIFICATION ROCHESTER SAMPLE NO	ROCK PROPERTIES SEDIMENTARY: SANDSTONE FINE GRAINED, BROWN TO DARK RED, MASSIVE	OR EET FO	COMP STRNTH KPS I	P.00	HAR Shore	SHORE SCHILDT	YOUNGS HOD. PSIXIOE6	POISSON	
•		166	11	9	*	98	4.47	6.24	

*6. ¥6. NOTES: 1-80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMED SPECIMEN. 4- INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HO210043-72.

PCT (=)	11.0
N. 2IN. 11N. 1/2IN. NO4 NOB NO16 NO30 NOSO NO100 NO200	3.0
NOSO NO	2.0 9.0 12.0 33.0 15.0 7.0 4.0 2.0 2.0
NO30	2.0
SCREENS	0.4 0.
T BETWEEN NOB	15.0
. BY WEIGH	33.0
PER CENT 11N. 1/	.0 12.0
IX. ZIX.	2.0 9
6IN. 3I	•
PCT(+)6 IV-517E	6
MOISTURE PCT	4.3
MUCK DATA DRY UNIT WT PCF	6

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGLAR SESUBANGLIAR REROUNDED PEPLATY CECUBIC INTREGULAR EMELONGATED SPESPHENDID

		0.33	SIZE(-)2.0 IN. ANGLE INTER FRICTION DEGREES AT	. 8.00
	TOUGHNESS	ė	_	7
∢	FLOW	7.20	BULK DENSITY PCF A1 8.48 PCT EG	93.1
•	0.0561N NSTICITY OEX	3 2	APPARENT BULK COMESIO! DENSITY PSF AT PCF AT B.48 PCT HOIST 8.48 PCT MOIST	550
<	PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	2.35	LIDE IN- LATE AT HOIST	36.33
er er	FRBERG LIMI SHRINKA LIMIT PCT	16.52	SIZE(-)2.0 ANGLE/S STEEL P DEGREFS 8.48 PCT	39
9 9	PLASTIC LIMIT PCT	17,35	ANGLE/REPOSE SIZE(-)2.6 IN ANGLE/REPOSE ANGLE/SLIDE IO IN DROP STEEL PLATE DEGREES AT DEGREES AT B.48 PCT HOIST R.48 PCT HOIST	41.26
u	L1901D L1M15 PC1	19.70		
		16	ANGLE/REPO ANGLE/REPO 1 IN DROP DEGPEES AT 8.48 PCT NO	42.30
	POT VOL CHANGE (+)0.056 IN.SIZE	•	(-)0.75 IN.SIZE ************************************	2,17

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POWER SYSTEM	PRIMARY SECONDARY 13200 640		SHOTCRETE			/OPERATE THRUST.MAX/OPERATE	CENTER KFTLB KLB 492			MUCKING GUIDANCE		
UTILITY LINES	AIR WATER PUMP BIN 4IN BIN		SET.SIZE.SHAPE			RPM TORQUE, MAX/OPERATE	HEAD.CENTER HEAD 11 30 KFTLB KFTLB364	ACING ADVANCE PER HOUR-FT. 9-5		BLASTING		
WATER INFLOW	6PM 4 0		ROCF PLATE 12FT 6IN OR 8FT 6 IN X	8 IN. 14 GAGUE)GES	GAGE 5 TCB ROLLER	THRUST/SQ FT KERF SPACING FEET KLB 1.86 0.28		Ton		GUNLESS STURE. SIDE RAIL YES.
	5T SIZE HP 48 IN 300	SUPPORT SYSTEM	80LT.TYPE SIZE SFT. 6FT. 8FTX 5/8 IN 24 IN.	CENTERS		E.DIAM.CUTTING EDGES	INTERIOR 24 DISC AND 2 TCB ROLLER	GUIDANCE THRU LASER KL9		EXPLOSIVES, POWDER FACTOR TOTAL LBS	TRIM INTERIOR CUT LIFTERS	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES.
VENTILATION	FM PRESS EXHST		SUPPLY RAIL		į	CUTTERS.MAKE.TYPE	CENTER 1-24 IN TCB TRI CO:IE	POWER SYSTEM ELECTRO- Hydraulic 960 mp		+0LES		RY SCREEN ANALY CREEN ANALYSIS APABILITY:CONVE
-	GRADE CFM +0.045PCT22K		PERSONNEL Rail			U	F 4 2	MUCK SYSTEM BUCKET TO BELT	AVATION	ROUND. NO. HOLES DEPTH DIAM.	cut.	S FOR MON IS O BY (N) FOR S SPORT SYSTEM C
Johnsell	SIZE SHAPE 19 FT ROUND 4 IN	HAULAGE SYSTEM	MUCK RAIL 10CY CARS 36 IN GARF	151 MOTOR 50 LB RAIL	MACHINE EXCAVATION		HAKE HODEL LAWRENCE HR] 1-8 1-8 4	ANCHOR PRESS M	CONVENTIONAL EXCAVATION	MACHINE JUMBO MACHINES	FEED LENGTH	BASI!

45A TUNNEL DATA

KEY

P01550N #ATTO	e.10 NOTE
YOUNGS MOD. PSIXIBE6	NOTE
SHORE SCHNIDT	NOTE
SHORE	4
PCT EST	8
COMP STANTH KPSI	LESS THAN 1
984 PCF	125
ROCK PROPERTIES SEDIMENTARY: SANDSTONE COARSE GRAINED. POORLY CONSOLIDATED. ARKOSIC. WITH MINOR LAYERS OF	MIN SEAMED SALISTONES
IDENTIFICATION MESTERN MUCLEAR SAMPLE NO	1-948

¥ ₩ **4** NOTES: 1. 88 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HO210043-72.

PCT (-) 24.9 : 14.0 16.0 12.0 17.0 5.0 2.0 3.3 | 5.7 11.7 PCT(+)6 IN-S17E MOISTURE PCT 10.5 MUCK DATA DRY UNIT 92

SCREEN ANALYSIS: UPPER LINE, DRY SCREENED : ASTH C136): AFTER WASHING (ASTM C117): LOWER LINE: SCREENED BEFORE DRYING

FRACTIONS BETWEEN SCREEN SIZES - ALAMBALAR SESUBAMBALAR REPOUNDED PEPLATY CECUBIC INTREBULAR EMELONGATED SPESPHERDID

STAFF OF THE LOAD OF WELL STAFFS STAFFS TO STAFFS STAFFS TO STAFFS TO STAFFS STAFFS STAFFS STAFFS		TODONESS	•••	SIZE(-)2.0 IN. AMBLE INTER FRICTION DEGREES AT 11 10.6 PCT MOIST
	∢	•	9	APPARENT BULK COMESTON DENSITY PSF AT PCF AT 10.6 PCT NOIST 0.4 PCT HOIST
31000	⋖	FLORE	7.40	BUL DEN DEN PCF PCF
	•	.8561N STICITY EX		APPARENT CCHESTON PSF AT 0.6 PCT N
	હ	SIZE(~) 0 PLA IND PCT	4.93	N. 15
	∢	PLASTIC SHRIMKAGE PLASTICITY LIMIT LIMIT PCT PCT	19.94	ANGLE/REPOSE ANGLE/SLIDE ANGLE/REPOSE ANGLE/SLIDE ANGLE/REPOSE STEEL PLATE DEGREES AT DEGREES AT 0.1 PCT HOIST 10.0 PCT HOIST
TODAW - W C 35	A F	PLASTIC LIMIT PCT	19.97	AMGLE/REPOSE 10 IN DROP DEGREES AT
INCEN SCHEEN SE	AE.	LIMITS PCT	24.90	0SE .1 .1
MAPE OF FRACTIONS OF		POT VOL CHANGE (-) 0.056 IN.SIZE		(-)0.75 IN.SIZE ************************************
		-	0	4.0

WNG-1 CURRENT: 04/01/73

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POWER SYSTEM	PRIMARY SECONDARY 440V 110V		SHOTCRETE IN GAD GROUND
UTILITY LINES	AIR WATER PUMP 41N		SET.SIZE.SHAPE
WATER INFLOW	GРМ 20 - 25		ROOF PLATE
TION	CFW PRESS EXMST SIZE HP 5-7K X 18IN	SUPPORT SYSTEM	SUPPLY GOLT-TYPE SIZE ROOF PLATE RAIL
VENTILATION	GRADE +0.5PCT		PERSONNEL Rail
TUNNEL	SIZE SHAPE 10FT X RECT 8FT	HAULAGE SYSTEM	MUCK Rail, 241M GAGE 40LB Rail

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46A TUNNEL DATA

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MACHINE			CUTTERS, MAKE, TYPE, DIAM, CUTTING EDGES	E.DIAM.CUTTI	NG EDGES	Z G	TORQUE.	TORQUE.MAX/OPERATE	THRUST . MAX/OPERATE
B-96	MONEL F6-A	Et 41	CENTER 72 KENNAMETAL U MOUNTED ON THIN	INTERIOR 43 K PICK BITS RIPPER HEADS	GAGE S	HEAD • C	MEAD.CENTER HEAD 60 KFILB KFILB	CENTER KFTLB KFTL9	מ ער ער
ANCHOR RLB	ANCHOR PRESS KLB	HUCK SYSTEM GATHERING ARI 14IN CHAIN CO 19IN BELT COI	HUCK SYSTEM FOWER SYSTEM GATHERING ARMS 440V ELECTRIC 14IN CHAIN CONV MOTORS 1AIN BELT CONV. 50.4HP HEAD TO REAR 2-20.2HP THRUS	GUIDANCE TRANSIT LASER JST	THRUST/SQ FT KLB NA	GUIDANCE THRUST/SG FT KERF SPACING ADVANCE PER TRANSIT FEET HOUR-FT. LASER KLB NA NA RA	ACVANCE PER Hour-FI. 2.0		

CONVENTIONAL EXCAVATION

BLASTING							
EXPLOSIVES.	POWDER FACTOR	TOTAL LBS	PRIMERS.	MIGH	INTERIOR	CUT	LIFTERS
ROUND.	NO. HOLES	ВРТН	DIAM.	cut.			
MACHINE	20#80	MACHINES			FEED LENGTH		

GUIDANCE

MUCK ING

BASIS FOR MDN. IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY: CONVENTIONAL RAIL YES SIDE RAIL YES.
FREE YEHICLES (4) BELI CONV. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES.
*POSSIBLE.TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
(4) EXCESSIVE ROADBED MAINTENANCE PROBABLE.

P01550N #AT10	NOTE S
YOUNGS MOD. PSIXIBE6	0.10 WOTE
SCHRIDT	NA NOTE
SHORE	*
#60 #C1	ê
COMP STRNTH KPSI	LESS THAN 1
ORY PCF	125
ROCK PROPERTIES SEDIMENTARY: SANDSTONE COARSE GRAINED. POORLY CONSOLIDATED. ARKOSIC. MITH MINOR LAYERS	OF THIN SEARCO SILTNOME. VARYING CONCENTRATIONS OF CARROWIFEROUS MATERIAL REPACTO BY SILICA.
IDENTIFICATION WESTERN NUCLEAR SAMPLE NO	4NG-2
KEY 47	

WOTES: 1. 80 PCT. OF FORMATION. ?. INFERRED FROM D.U.DEERE AD 646610-66. 3. UNPOLISMED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. 6. FROM CSM A.R.HOZ10043-72.

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGAR SESUBANGUL/R REROUNDED PEPLATY CECUBIC IMIRREGULAR FELONGATED SFESPMERGID PCT (-) 20.1 SCREEN ANALYSIS: UPPER LINE, DRY SCREENED (ASTM C136), AFTER WASHING (ASTM C117), LOWER LINE, SCREENED BEFORE DRYING 61N. 31N. 21N. 11N. 1/21N. WO4 NOS NOIG NOSO NOSO NOIGO NOSO 7.9 16.0 16.0 11.0 16.0 5.0 4.0 7.3 8.7 5.4 7.9 PCT(+)6 IN-SIZE 00 MOISTURE PCT 8.3 HUCK DATA DRY UNIT WT PCF 8

TOLOWESS	0.13	SIZE(~)2.0 IM. AMGLE INTER FRICTION DEGMEES AT 9.0 PCT MOIST	2
FLOW TOUGHNESS INDEX	•••	BULK DENSITY PCF AT T 0.0 PCT MOIST	*
PLASTICITY INDEX PCT	0.51	INAPPARENT B AT COMESION D AT PSF AT P MOIST 9.0 PCT MOIST 0.	•
PLASTIC SHRINKAGE PLASTICITY LIMIT LIMIT PCT PCT	23.37	IZE(-)2.0 IN ANGLE/SLIDE STEEL PLATE DEGREES AT 9.0 PCT MOIST	•
PLASTIC LIMIT PCI	24.74	AMGLE/REPOSE AMGLE/SLIDE IN DROP STEEL PLATE DEGREES AT DEGREES AT DEGREES AT 9.0 PCT MOIST	31
LIOUID LIMITS PCT	25.25	MGLE/REPOSE JN. DROP EGREES AT .0 PCT MOIST	32
POT VOL CHANGE (-)0.056 IN.SIZE	•	GRAVITY DEGREES AT MOIST	2.72

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WNG-2 CURRENT: 04/01/73

GUIDANCE TRANSIT

				CONDARY		
Princeton Prince	-		POWER SYSTEM	PRIMARY SECONDARY 446V 116V		RETE
	•		Q.	ā.		SHOTCRETE
· ·				Ç H Ş		ų.
)			UTILITY LINES	AIR WATER PUMP 21N 11N		SET+S12E+SHAPE
į			5	214		SEI
			WATER INFLOW	GPN VAY		BOLT.TYPE SIZE ROOF PLATE
				<u>a</u>	SUPPORT SYSTEM	PE SIZE
				SIZE	SUPPORT	BOLT.TY
			AT10N	CFH PRESS EXHST S-7K X		SUPPLY Rail Air Hoist
			VENTILATI	S-7K		
				GRADE VARIES		PERSONNEL Rail
		DATA		SHAPE	SYSTEM	RAPER
	KEY	47A TUNNEL DATA	TUNNEL	S12E 5F1 X 9FT	HAULAGE SYSTEM	MUCK 421N SCRAPER RAIL

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MACHINE	Ę.			CUTTERS.HAKE.TYPE.DIAM.CUTTING EDGES	E.DIAM.CUTTI	NG EDGES	Apa		TOROUE, MAX/OPERATE	K/OPERATE	THRUST. HAX/OPERATE
MAKE	E MODEL	ĬĒ.	<u>-</u>	CENTER	INTERIOR	GAGE	HEAD . CI	HEAD.CENTER HEAD	HEAD	CENTER	
B-98									KFTLB KFTLB	XFTL® XFTL®	8 K K K
	ANCHOR PRESS MUCK SYSTEM	MUCK	SYSTEH	POWER SYSTEM	GUIDANCE	THRUST/SO FT	GUIDANCE THRUST/SQ FT KERF SPACING ADVANCE PER	NDVANCE	PER		
RLB						KLB	FEET	HOCK	• •		

CONVENTIONAL EXCAVATION

MUCKING SCRAPER	ENGE 2 OF NOW
BLASTING SAFETY FUSE. CAPS	*. <u>.</u>
EXPLOSIVES. POWDER FACTOR S.OLB/CY TOTAL LBS SO. 40PCT GELEX 2 PRIMERS. TRIM INTERIOR CUT	BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCPEEN ANALYSIS WITH NATURAL MOISTURE, TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES+ FREE VEHICLES (4) BELI CONV. (?) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES+ *POSSIBLE,TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE. (4) EXCESSIVE POADBED MAINTENANCE PROBABLE.
ROUND. NO. HOLES 18 DEPTH 6FT DIAM. 1.SIN CUT. RURN 5 HOLE SF/HOLE 2.5	DN IS DRY SCREEN ANALYSIS I 1) FOR SCREEN ANALYSIS I YSTEH CAPABILITY:CONVEN ES (4) BELT CONV. (2) I ECHNOLOGY NOT FULLY DEN VE POADBED MAINTEMANCE
MACHINE JUMBO MACHINES LE ROI MOD35-AIRLEG FLED LENGTH GFT	BASIS FOR M NOTED BY (N TRANSPORT S FREF VEHICL! *POSSIBLE*TI

PO1550N RAT10	otos STE
YOUNGS #00.	
DMESS SCHMIDT	NA NOTE
SHORE	\$
6 4 4 6 4 4 6 4 4 4	. S1
COMP STRNTH KPS I	LESS
DRY PCF	. E
ROCK PROPERTIES SEDIMENTARY: SANDSTONE ARKOSIC IMPEGULARLY BEDDED, LOOSELY COMSCHIDATED WITH LAYERS AND	LENSES OF SILTY MUDSTONE.
IDENTIFICATION SAN FERNANDO SAMPLE NO	SF-1

X Y

. 3. UMPOLISHED SPECIMEN. 6. FROM CSM A.R.H0210043-72. NOTES: 1. 80 PCT. OF FORMATION. 2. INFERRED FROM D.U.DEERE AD 646610-66. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. (

PCT (-)	36.4
	12.8
080 NO	.0 0.0 2.2 4.5 6.1 5.1 7.0 11.5 14.4 12.8
#03 0	11.5
SCREENS	5.1 7.0
T BETWEEN NOB	6.1
7 8Y WEIGH 721N• NO4	4.5
PER CEN	.0 2.2
37.4. 21N.	0.0
PIE NI9	0.0
PCT(+)6 IN-SIZE	0.0
MOISTURE PCT	19.5
PUCK DATA DRY UNIT HT PCF	16

SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGAR SESUBANGULAR REROUNDED POPLATY CECUBIC IMIRREGULAR EMELONGATED. SPASPHEROLD

TOUGHNESS INDEX 0.27		?
FLOW	BULK BULK DEWSITY PCF AT 0.0 PCT MOIST	**
•	0151	4
INITS.SIZE(-) MKAGE PL IN IN PC 94 3.5	185 IN E/SLIDE L PLATE EES AT PCT MOIST	*
ATTERBERG L SHRIG LIMI PCT 13.	IAL SIZE(-)0 SE SHEE DEGREES	
	ANGLE/REPOS 10 IN DROP DEGREES AT	33
	MGLE/REPOSE I IN DROP REGREES AT	38
POT VOL CHANGE (=)0.065 IN.SI;	(+)0.185IN.SIZE (SPECIF)	2.86
	D PLASTIC SHRIMMAGE PLASTICITY FLOW TO SHRIMM	LIOUID PLASTIC SHRIMMAGE PLASTICITY FLOW LIMITS LIMIT LIMIT INDEX LIMITS LIMIT LIMIT INDEX LIMITS LIMIT LIMIT INDEX LIMITS LIMIT LIMIT INDEX IT.75 PCT PCT PCT IT.75 I6.19 I3.94 3.56 5.8 GLE/REPOSE ANGLE/SLIDE APPARENT BULK IN DROP 19 IN DROP STEEL PLATE COMESION DENSITY 3 PCT MOIST 14.3 PCT MOIST 12.5 PCT MOIST 0.0 PCT MOI

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RENT: 04/01/73

GUIDANCE

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BLAST ING

BASIS FOR MDN IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL FAIL YES SIDE RAIL YES.
FREE YEHICLES (4) BELT CONV. (2) HYDRAULIC PIPELINE YES PNEUMATIC PIPELINE YES.
*POSSIBLE-TECHNOLOGY NOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE.
(4) EXCESSIVE ROADBED MAINTENANCE PROBABLE.

PRIMARY SECONDARY 4160V 450V POWER SYSTEM SHOTCRETE SET.SIZE.SHAPE
CONTINUO'S PRECASI
CONCRETE BIN OR
101N THICK X
4FT - 4 SEGMENT PUMP 6 I N UTILITY LINES WATER AIA WATER INFLOW ROOF PLATE 69 H 2002 BOLT, TYPE SIZE SUPPORT SYSTEM £ PRESS EXHST FACE X SUPPLY RAIL VENTILATION GRADE CFM +0.25PCT 20K PERSONNEL Raii SHAPE SYSTEM 48A TUNNEL DATA

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MACHINE EXCAVATION

HAULAGE

MUCK RAIL

TONNEL S12E 21FT

K K

THRUST.MAX/OPERATE	KLB 7000 KLB	
TORQUE . HAX/OPERATE	HEAD CENTER KFTLB KFTLB DNA KFTLB DNA	e R
	HEAD.CENTER HE	G ADVANCE PHOUR.FT
M dà	NA ON ON ON ON ON ON ON ON ON ON ON ON ON	KERF SPACIN FEET DNA
CUTTERS.NAKE.TYPE.DIAM.CUTTING EDGES	GAGE 1001H	GUIDANCE THRUST/SO FT KERF SPACING ADVANCE PER L'f_r ker hour. Dna 24
	INTERIOR OPERATED RIMPER	GUIDANCE L'FS_R
UTTERS+MAKE+TYPE	CENTER Hydraul IC	POWER SYSTEM HYDRAULIC
O	285 1085	MUCK SYSTEM BUCKET TO 6FT CONVEYOR TO REAR
MACHINE	HAKE MODEL S21S PER PREED SHIELD	ATCHOR PRESS MEKE

CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS,	INTERIOR CUT I IFTERS
ROUND. NO. HOLES DEPTH DIAM.	• • • • • • • • • • • • • • • • • • • •
HACHTNE JUMBO HACHINES	FEED LENGTH

SHORE SCHIIDT	~
SHORE	¥
ROD PCT EST	20
COMP STRNTH KPSI	~
ORY PCF	142
ROCK PROPERTIES SEDIMENTARY: SANDSTONE AND BIOTITE RICH SILTSTONE, POORLY TO WELL CONSOLIDATED, POORLY TO WELL SORTED.	
IDENTIFICATION SAN FERNANDO SAMPLE NO SF-2	

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0.10 NOTE

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NOTE

YOUNGS MOD. PSIX10E6

NOT": 1. bu PCT. OF FORMATION. 2. INFERNED FROM D.U.DEERE AD 646610-66. 3. UMPOLISHED SPECIMEN. 4. INFERRED FROM TESTS/SIMILAR ROCK. 5. ASSIGNED MINIMUM VALUE. F. FROM CSM A.R.HOZIOO43-72.

MOISTURE PCT(+)6 *PER CENT BY k_lGHT BETWEEM SCREENS	19.0	DRYING	SHAPE OF FRACTIONS BETWEEN SCREEN SIZES AMANGAR S#SUBANGULAR R#ROUNDED P#PLATY C#CUBIC I*IRREGULAR F#ELONGATED SF#SPMEROID
NOTO	10.8	EENED BEFORE	LAR F=ELONGA
NOSO	5. 9.5	I LINE. SCR	IC 1=IRREGU
0E0N	1.5	. LOWER	r c=cu81
CREENS.	9.0	# C117)	P=PLAT
TWEEN S	0	NG (AST	ROUNDED
16HT BE NO4	ê. 0 ê.	ER WASHE	BULAR R=
NT BY E.	0.0 8.6 14.4 34.6 0.5 0.6 0.8	6) . AFTE	S=SUBANG
PER CE	.6 14.	ASTH C13	INGUL AR
IN ZIN	6	CREENED (.	SIZES A=
* 6IN. 3	• • • •	E. DRY S	SCREEN
CT(+)6 4.SIZE	0.0 10	PER LIN	BETWEEN
MOISTURE PC	17.5 0.	SCREEN AMALYSIS: UPPER LINE, DRY SCREENED (ASTH C136), AFTER WASHING (ASTM C117), LOWER LINE, SCREENED BEFORE DRYING	OF FRACTIONS
MUCK DATA DRY UNIT N WI PCF F	90	SCREEN	SHAPE

SF-SPHERO		
F=ELONGATED		Johne SS De X
N SIZES - A=AMGULAR S=SUBANGULAR R=ROUNDED P=PLATY C=CUBIC I=IRREGULAR F=ELONGATED SFASPMERO	3	PLASTIC SHRINKAGE PLASTICITY FLOW TOUGHNESS LIMIT LIMIT PCT POT POT
C=CU 8 1C	15	INI
P=PLATY	15	56 IN
ROUNDED	51	E (-) 0.0 PLAST INDEX PCT
AR R	15	512
S#SUBANGUL	Is	ERG LIMITS Shrinkage Limit PCT
E AR	Š	TERBE
A=ANG	S.	TIC.
SIZES	4	PLAS
N SCREEN	ğ.	LIQUID LIMITS PCT
ETVEE		ַבְּבָּי. בַּבָּבָי.
SMAPE OF FRACTIONS BETWEEN SCREE	¥.	POT 4OL CHANGE (-)0.056 IN.SIZE
16 J		,01 €
ž Ž		P01 (-)

SIZE(-)1.0 IN. ANGLE INTER FRICTION DEGREES AT 15 PCT MOIST	75
BULK DENSITY PCF AT 0 PCT MOIST	75.36
IN APPARENT BULK ATE COMESION DENSITY AT PSF AT PCF AT MOIST 1S PCT MOIST 0 PCT MOIST	80
ANGLE/REPOSE ANGLE/SLIDE 10 IN DROP STEEL PLATE DEGREES A7 DEGREES AT 15.1 PCT HOIST 15.1 PCT HOIST	30
ANGLE/REPOSE 10 IN DROP DEGREES A7 15.1 PCT HOIST	36
SPECIF ANGLE/REPOSE GRAVITY 1 IN DROP DEGREES AT 15.1 PCT HOIST	38
(-)0.75 IN.S Specif Gravity	3.02

0.61

7.6

4.7

21.5

26.8

31.5

1

DATA TUNNEL ž

d NI 9 UTILITY LINES WATER AIR 6 In MATER INFLOW å 3212E 361N PPLSS EXHST FACE X VENTILATION CF. GRADE +0.25PCT SHAPE TRANS S12E 21f T

SECONDARY 480V

PR I HARY 4160V

SHOTCRETE

SET.SIZE.SM/PE CONTINUOUS PRECAST CONCRETE GIN OR 101N THICK X 4FT - 4 SEGMENT

ROOF PLATE

BOLT.TYPE SIZE

SUPPLY RAIL

PERSONNEL Rail

MUCK RAIL

SYSTEM

HAULAGE

SUPPORT SYSTEM

POWER SYSTEM

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NACHINE EXCAVATION

THRUST . HAX/OPERATE KLR 7000 KLB KFTLB KFTLB DNA TORQUE . MAX/OPERATE A O N O NFTLB KFYLB HEAD KERF SPACING ADVANCE PER FEET HOUR-FT. HEAD.CENTER DNA ğ THRUST/SO FT GAGE KLB DNA CUTTERS.MAKE.TYPE.DIAM.CUTTING EDGES INTERIOR OPERATED RIPPER GUIDANCE LASER HYDRAUL IC POWER SYSTEM HYDRAULIC CENTER MUCK SYSTEM BUCKET TO 6FT CONYEYDR TO REAR 285 1085 MODEL 2215 RIPPER SHIELD ANCHOR PRESS MAKE ROBBINS MACH INE ALE B -102 B

CONVENTIONAL EXCAVATION

EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMFRS.	TRIM INTERIOR CUT
ROUND+ NO. HOLES DEPTH	cut.
MACHINE LUMBO MACHINES	FEED LENGTH

GUIDANCE

MUCK ING

BLASTING

BASIS FOR HOL IS DRY SCREEN ANALYSIS AFTER WASHING UNLESS NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE. TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES. FREE VEMICLES (4) BELT CONV. (2) HYBRALIC PIPELINE YES PNEUMATIC PIPELINE YES. POSSIBLE.TECHNOLOGY MOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUILDUP PROBABLE. (4) EXCESSIVE ROADBED MAINTENANCE PROBABLE.

SF-2 CURRENT: 04/01/73

			PCT (-) 40200	59.6	6	*SPHEROID				*
POISSON RATIO	8.10 8.10 8.10		00200		LOWER LINE. SCREENED BEFORE DRYING	C=CUBIC 1=IRREGULAR F=ELONGATED SP=SPMEROID		• • • • • • • • • • • • • • • • • • •		SIZE(-)2.0 I ANGLE INTER FRICTION DEGREES AT
YOUNGS HOD. PSIXIDE6	NOTE O		000	12.5	REENED BEF	JLAR F=ELO		TOUGHNESS	0.92	s =
SHORE SCHMIDT	42 NOTE		0.00.0	6.3	LINE. SCH	C 1=IRREGU	◄	FLOW	3,60	BULK DENSITY PCF AT
SHORE	4	CIMEN. 10043-7	1030 1030	Ŋ.		C=CUB I	⋖		n	•
800 PCT EST	\$	3. UNPOLISMED SPECIMEN. 6. FROM CSM A.R.HO210043-72	SCREENS	3 2.7	(AST# C117) •	S#SUBANGULAR R*ROUNDED P#PLATY	•	0561N TICITY X		APPARENT CONESION PSF AT 10.9 PCT MOIST
COMP STRNTH KPSI	11	. UNPOLI	TWEEN S	m		ROUNDED	•	"LASTIC SHRINKAGE SIZE(") 0.056IN." "LASTIC SHRINKAGE PLASTICITY LIMI LIMIF PCT PCT	3.33	
-		-66. 3. E. 6. F	E1GHT BE NO4	.9 0.3	ER WASHING	GULAR R	∢	175517 AGE		LIDE LATE AT MOIS
DRY #T	*	M D.U.DEERE AD 646610-6 ASSIGNED HINIMUM VALUE.	NT BY W	28.9	C136) . AFTER	S=SUBAN	•	ERG LIM SHRINK LIMIT PCT	19.12	SIZE(-)2.00 ANGLE/SLIDE STEEL PLATE DEGREES AT 12.7 PCT MOI
INE.		DEERE AD ED HINIM	PER CE	1.9 5.2 11.0 6.4	(4STH C13	A=ANGULAR	1	. ATTERB		
TONE. DARK D. MASSIVE.			**************************************	5.9 8.4 1)	EENED (Id	PLASTIC LIMIT PCT	24.97	TE T
RTIES NY: MUDS GRAINE		٥	••••••••••••••••••••••••••••••••••••••	0.0 20.1	LINE. DRY SCREENED	REEN SI	PE			ANG 10 0E 0E
ROCK PROPERTIES SEDIMENTARY: MUDSI GRAY: FINE GRAINED		2. INFERRED MILAR ROCK.	_		R LINE.	SHAPE OF FRACTIONS BETWEEN SCREEN SIJES		LIGUIN LIMITS PCT	28.30	ANGLE/RFPOSE 1 IN DROP DEGREES AT
5 2 g		IATION. ESTS/SI	E PCT(+)6 IN-SIZE	0.0	: UPPER	TONS BE	Ž.	<u> </u>		
ICAT 10N		OF FORM	MOISTURE PCT	7. 6	ANAL YSIS:	F FRACT		POT VOL CHANGE (+)0.056 IN.SIZE		(-)0.75 IN.SIZE Specif Gravity
IDENTIFICATION KERR- HCGEE SAMPLE ND	 I X	NOTES: 1.80 PCT. OF FORMATION. 2. INFERRE: 4. INFERRED FROM TESTS/SIMILAR ROCK.	K DATA Y IJNIT PCF	91	SCREEN A	SHAPE		POT VOL (-) 0.056	0	(-)0.75 SPECIF GRAVITY
χ 00.		NOT	MUCK E T				B-103			

B-103

2

37

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82

54

2.87

TUNNEL DATA 50 A ₹ F

UTILITY LINES MATER INFLOW ROOF PLATE 98 1 X BOLT.TYPE SIZE SUPPORT SYSTEM ቆ የር S12E 24 IN PRESS EXHST FACE VENT SUPPLY RAIL VENTILATION F X GRADE +0.SPCT PERSONNEL Rail RAIL. 36IN GAGE SHAPE SYSTEM HAULAGE CUNNEL \$12E 10FT 9FT

AIR MATER PUMP SET SIZE SHAPE AIN WE STEEL . SETS AT BET OR 6FT

SHOTCRETE

PRIMARY SECONDARY POWER SYSTEM

1

.

MACHINE EXCAVATION

TOROUE . MAX/OPERATE ž KF7LB KF7LB HEAD HEAD.CENTER 78 300 GAGE MOUNTED CUTTERS, MAKE, TYPE, DIAM, CUTTING EDGES INTERIOR 43 KH PICK BITS HEADS CENTER 40 KENNAMETAL U ON TWIN RIPPER 11 11 10NS MODEL F6-A MAKE ALPINE MINER MACHINE B-104

CENTER KFTLB NA

ACVANCE PER HOUR.FT. NA

KERF SPACING FEET

THRUST/SO FT

KLB NA

POWER SYSTEM GUIDANCE ELECTRIC MOTORS TRANSIT 50.4HP HEAD LASER 2-20.4HP THRUST

MUCK SYSTEM GATHERING ARMS 14IN FLIGHT CONVEYOR

ANCHOR PRESS

THRUST . MAX/OPERATE

CONVENTIONAL EXCAVATION

ROUMD. NO. HOLES DEPTH DIAM. CUT. MACHINES JUMBO MACHINES

FEED LENGTH

EXPLOSIVES, POWDER FACTOR TOTAL LBS PRIMERS, TRIM

GUIDANCE

MUCKING

BLASTING

INTERIOR CUT LIFTERS

BASIS FOR MDA IS DRY SCREEN ANALYSIS AFTER MASHING UNLESS
NOTED BY (N) FOR SCREEN ANALYSIS WITH NATURAL MOISTURE.
TRANSPORT SYSTEM CAPABILITY:CONVENTIONAL RAIL YES SIDE RAIL YES.
**PROSTIBLE: (4) BELT CONV. (2) MYDRANLIC PIPELINE YES PNEUMATIC PIPELINE YES.
**POSSIBLE:TECHNOLOGY MOT FULLY DEVELOPED. (2) EXCESSIVE FINES BUJLDUP PROBABLE.
(4) EXCESSIVE ROADBED MAINTENANCE PROBABLE.

KN-1 CURRENT: 04/01/73 HOV 4 OR 1 (N)

APPENDIX C
SYSTEM DATA SHEETS

Identification	Page	Identification	Page
NAST-1	C-1-C-2	5-1	
NAST-2	C-3-C-4	7-2	C-53-C-54
NAST-3	C-5-C-6	11-3	C-55-C-56
NAST-4	C-7-C-8	11-4	C-57-C-58
GA-I	C-9-C-10	72-1	C-59-C-60
H-1	C-11-C-12	MSU-1	C-61-C-62
H-2	C-13-C-14	MSU-2	C-63-C-64
H-3	C-15-C-16	LAW-2	C-65-C-66
LK-1	C-17-C-18	LAW-3	C-67-C-68
LK-2	C-19-C-20	LAW-4	C-69-C-70
LK-5	C-21-C-22	MIL-1	C-71-C-72
LK-6	C-23-C-24	MIL-2	C-73-C-74
LK-7	C-25-C-26	MIL-3	C-75-C-76
SM-1	C-27-C-28	EVG-1	C-77-C-78
CL-1	C-29-C-30	EVG-2	C-79-C-80
LK-3	C-31-C-32	LAY-1	C-81-C-82
LK-4	C-33-C-34	LAY-2	C-83-C-84
MB-1	C-35-C-36	CNT-I	C-85-C-86
MB-3	C-37-C-38		C-87-C-88
ST-1	C-39-C-40	NA V - 1 NA V - 2	C-89-C-90
CR-1	C-41-C-42		C-91-C-92
HS-1	C-43-C-44	RO-1	C-93-C-94
NY-1	C-45-C-46	WNG-1	C-95-C-96
NY-2	C-47-C-48	WNG-2	C-97-C-98
QL-1	C-49-C-50	SF-1	C-99-C-100
MB-2	C-51-C-52	SF-2	C-101-G-102
	= 02 0 50	KM-I	C-103-C-104

Lithology: Igneous, granite, gray, medium to fine grained, moderately to slightly fractured and jointed, 10 to 20% quartz, 50 to 60% feldspar, balance dark minerals.

Uniaxial Compressive Strength: 18 KPSI.

RQD: (Estimated) 90%.

Dry Unit Weight: 167 PCF.

Ground Water: Minor, primarily from fault zones.

Hardness: Schmidt 51 (Note 4).

Youngs Mod.: $8.50 \text{ PSI} \times 10^6 \text{ (Note 2)}$.

Poisson Ratio: 0.30 (Note 2).

TUNNEL DATA:

Size: 9' 9" diameter. Grade: (+) 0.22%.

Ventilation System: 10 KCFM, exhaust, 22" pipe to rear of conveyor,

16" to face.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5 to 20 gpm. Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage,

Support System: 4" ring and half sets, at 4', 3' and 2' centers in bad ground, 13" wide x 10' - 16 gage plates secured by 4-1" x 7' grouted bolts as required.

EXCAVATION DATA:

Machine: Wirth Erkelenz, Hardrock Model. Weight: 67 tons.

Cutters: 25 Hughes Tool/Wirth Tungsten Carbide Button. Gage: 6-11 1/2" TCB roller. Interior: 15-11 1/2" TCB roller. Center: 2-11 1/2" roller and 2-11 1/2" TCB Cone.

Rotation: Head, 8 1/2 RPM

Torque: 150 K ft. # max., 110 K ft. # operating

Thrust: 290 K lbs.

Muck System: Bucket from face, 22" belt conveyor to rear.

Power System: 3-200 HP electric motor driven hydraulic pumps driving

four hydraulic head motors and the thrust and anchor cylinders.

Guidance System: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966. NOTE 4: Inferred from Tests of Similar Specimens.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. NAST-1

MDN

Take T

Abrasiveness N. A. Pot. Vol. Change, Material Size (*) 0.065" : 0

Spec. Gravity, Material Size(-) 0.50": 2.69

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.185 IN.

Liquid Limit 14.50%
Plasticity Index 0.50%

Plastic Limit 14.00 % Toughness Index 0.16 Shrinkage Limit 13.50 % Flow Index 3.0

MATERIAL SIZE (-) 0.50 IN.

Angle/Repose 1" Drop

9.0 % Moisture, 370

Angle Slide Steel Plate

Apparent Cohesion PSF

Moisture, NA

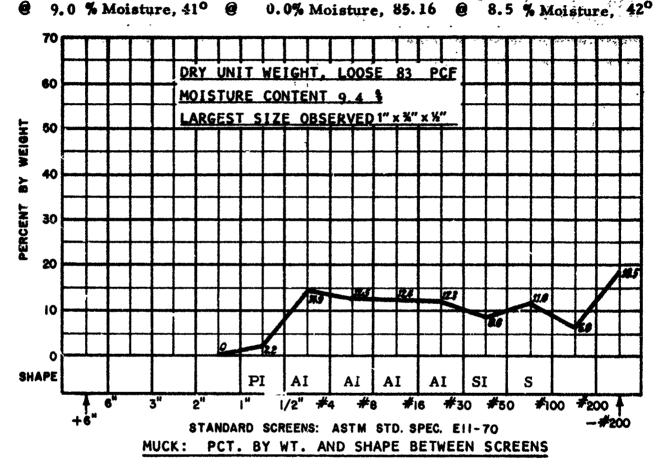
Bulk Density PCF

Angle/Repose 10" Drop

9.0 % Moisture, 360

Angle Internal Friction

9.5 % Moisture, 420



SUMMARY

Rock Class: Igneous: Granite, moderately to slightly fractured and jointed. Medium to fine grained. High strength. RQD (Est.) 90%. DUW: 167 PCF. Ground water: Minor. Hardness: Schmidt 51.

System Class: TBM, Wirth Erkelenz, Hardrock, 9'9" dia. 25 Hughes Tool/Wirth TCB roller and cone cutters. RPM: 8-1/2, 110 K ft # Torque, 290 K# Thrust. Mucking: Buckets to belt. Haulage: Rail. Support: Steel ring and half sets, roofplates and rock bolts.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NAST-1 Sheet 2

Lithology: Igneous, granite, gray, medium to fine grained, moderately to slightly fractured and jointed, 10% to 20% quartz, 50% to 60% feldspar, balance dark minerals.

Uniaxial Compressive Strength: 18 KPSI.

RQD: (Estimated) 90%.

Dry Unit Weight: 167 PCF.

Ground Water: Minor, primarily from fault zones.

Hardness: Schmidt 51 (Note 4).

Youngs Mod.: 8.50 PSI x 106 (Note 2).

Poisson Ratio: 0.30 (Note 2).

TUNNEL DATA:

Size: 9'9" diameter. Grade: (+) 0.22%.

Ventilation System: 10 KCFM, exhaust, 22" pipe to rear of conveyor,

16" to face.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5 to 20 gpm. Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage 70# rail.

Support System: 4" ring and half sets, at 4', 3' and 2' centers in bad

ground (approximately 650'), 13" wide x 10' - 16 gage plates secured by

4-1" x 7' grouted bolts as required, (approximately 1200').

EXCAVATION DATA:

Machine: Wirth Erkelenz, Hardroc! Model. Weight 67 tons.

Cutters: 25 Hughes Tool/Wirth Tungsten Carbide Button. Gage: 6-11 1/2" TCB roller. Interior: 15-11 1/2" TCB roller. Center: 2-11 1/2" roller and 2-11 1/2" TCB cone.

Rotation: 8 1/2 RPM

Torque: 150 K ft # max., 100 K ft. # operating.

Thrust: 290 K lbs

Muck System: Bucket from face, 22" belt conveyor to rear.

Power System: 3-200 HP electric motor driven hydraulic pumps driving

four hydraulic head motors and the thrust and anchor cylinders.

Guidance System: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966. NOTE 4: Inferred from Tests of Similar Specimens.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NAST-2 Sheet 1

Ab	rasivenes	5
N	A	

Pot. Vol. Change. Material Size (-)0.056": 0

Spec. Gravity, Material Size (-) 0.50" : 2.66

ATTERBERG LIMITS, MATERIAL SIZE (-)C. 056 IN.

Liquid Limit 19.5 %

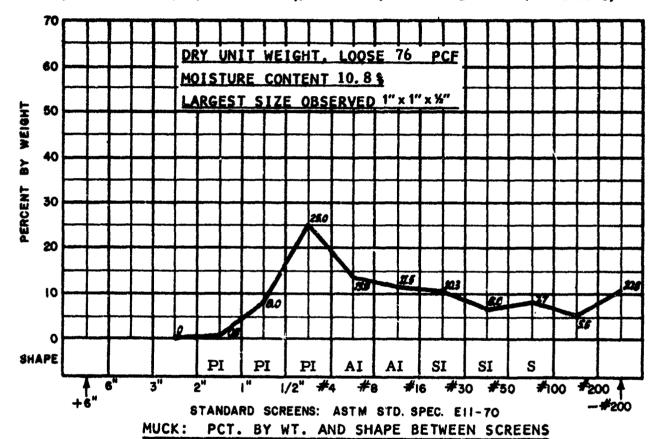
Plastic Limit 18.2% Plasticity Index 1.3 % Toughness Index 0.28

Shrinkage Limit 17.9 % Flow Index 4.6

MATERIAL SIZE (-)1.0 IN.

Angle/Repose 1" Drop 8.7 % Moisture, 38⁰ Angle Slide Steel Plate

Apparent Cohesion PSF 8.5% Moisture. 0 **Bulk Density PCF** 8.7 % Moisture, 49° @ 0.0% Moisture, 84.53 Angle/Repose 10" Drop 8.7 % Moisture. 380 Angle Internal Friction 8.5 % Moisture, 31



SUMMARY

Rock Class: Igneous: Granite, medium to fine grained, moderately to slightly fractured and jointed. High strength. RQD: (Est.) 90%. DUW: 167 PCF. Ground water: Minor. Hardness: Schmidt 51.

System Class: TBM, Wirth Erkelenz, Hardrock. 9' 9" dia. 25 Hughes Tool/ Wirth TCB roller and tricone cutters. RPM: 8-1/2, 100 K ft # Torque, 290 K# Thrust. Mucking: Buckets to belt. Haulage: Rail. Support: 4" ring and half sets, roof plates and rock bolts.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

NAST-2 Ident. No. Sheet 2

Lithology: Igneous, biotitic granite, finc grained, with major quartz and

minor feldspar and dark mineral contents.

Uniaxial Compressive Strength: 28 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 164 PCF.

Ground Water: Minor, from fault zones. Hardness: Shore 99.2, Schmidt 54 (Note 2).

Youngs Mod.: 8.3210 PSI x 10⁶ Poisson Ratio: 0.35 (Note 2).

TUNNEL DATA:

Size: 10' high x 16' wide x 8', alcove from 9'-9" diameter tunnel.

Ventilation System: 10 KCFM, exhaust, 22" pipe.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5-10 GPM.

Power System: Not applicable.

Haulage System: Muck, personnel, supplies by rail cars, 36"Gage, 70# rail. Support System: 1" x 7' grouted rock bolts and 13" x 10'-16 gage roof plates.

EXCAVATION DATA:

Conventional Rail Haulage System.

Drilling: 2-S53F, 4' feed, jack legs.

Drill Round: 72 holes, 1 3/4" diameter, 9' av. depth, double V-cut.

Explosives: 300# Gelex #2-60%. Powder Factor, 6.3#/CY.

Blasting: Electrical, zero and 7 regular delays.

Mucking: Diesel front end loader, 1/2 CY.

Guidance: Not applicable.

NOTE 2: Inferred from D. U. Deere AD646610-1966.

Abrasiveness N. A.

(-)

12

Pot. Vol. Change, Material Size(-)0.056": 0

Spec. Gravity, Material Size (-)0.75": 2.65

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 19.50% Plasticity Index 2.09 % Plastic Limit 17.41% Toughness Index 0.51 Shrinkage Limit 17.13% Flow Index 4.10

MATERIAL SIZE (-) 2.0 IN.

0.0% Moisture, 91.2

Angle/Repose 1" Drop

@ 2,8 % Moisture, 39°
Angle Slide Steel Plate

@ 2.8 % Moisture, 31°

Apparent Cohesion PSF

② 3.0 % Moisture, 80

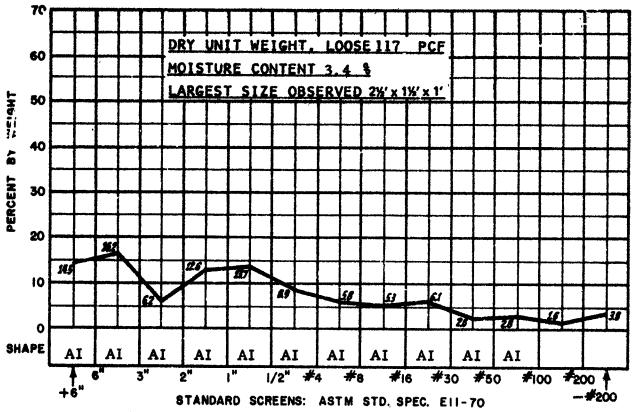
Bulk Density PCF

Angle/Repose 10" Drop

@ 2.8 % Moisture, 36°

Angle Internal Friction

@ 3.0 % Moisture, 38°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Igneous: Granite, biotitic, fine grained. High strength. RQD (Est.) 90%. DUW: 164 PCF. Ground water: Minor. Hardness: Shore 99.2, Schmidt 54.

System Class: Conventional Rail. 10' high x 16' wide x 8' alcove. Two jack leg drills, 72-9' holes, double V-cut. PF 6.3#/CY. Mucking: Diesel front end loader, 1/2 CY. Haulage: Rail. Support: Grouted rock bolts and roof plates.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident, No. NAST-3

2

Sheet 2

Lithology: Igneous, granite, fine grained, moderately fractured, major

quartz and minor feldspar and dark mineral contents.

Uniaxial Compressive Strength: 24 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 160 PCF.

Ground Water: Minor, primarily from fault zones.

Hardness: Schmidt 54 (Note 2).

Youngs Mod.: 8.30 PSI x 10^6 (Note 2).

Poisson Ratio: 0.33 (Note 2).

TUNNEL DATA:

Size: 9-'10" diameter. Grade: (+) 0.22%.

Ventilation System: 10 KCFM, exhaust, 22" pipe to rear of conveyor, 16" to face.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 5 to 20 gpm. Power System: 4160/480 V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage 70# rail. Support System: 4" ring and half sets, at 4', 3' and 2' centers in bad ground (approximately 650'), 13" wide x 10' - 16 gage plates secured by 4-1" x 7' grouted bolts as required, (approximately 1200').

EXCAVATION DATA:

Machine: Wirth Erkelenz, Hardrock Model (Modified)*. Weight 67 tons. Cutters: 29 Hughes Tool Tungsten Carbide Button. Gage: 6-11 1/2" TCB roller. Interior: 19-11 1/2" TCB roller. Center: 2-11 1/2" roller and 2-11 1/2" TCB cone.

Rotation: 8 1/2 RPM.

Torque: 150 K ft. # max , 125 K ft # operating.

Thrust: 630 K lbs.

Muck System: Bucket from face, 22" belt conveyor to rear.

Power System: 3-200 HP electric motor driven hydraulic pumps driving

four hydraulic motors and the thrust and anchor cylinders.

Guidance System: Laser

*Modified by replacement of original by a Hughes Tool Co. cutting head and cutters.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NAST-4 Sheet 1

Abrasiveness N. A.

1

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Pot. Vol. Change, Material Size (-)0.056 : 0

Spec. Gravity, Material Size (-) 0.75: 2.64

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 19.20%

Plastic Limit 18.97% Plasticity Index 0.23 % Toughness Index 0.06 Shrinkage Limit 17.50% Flow Index 3.40

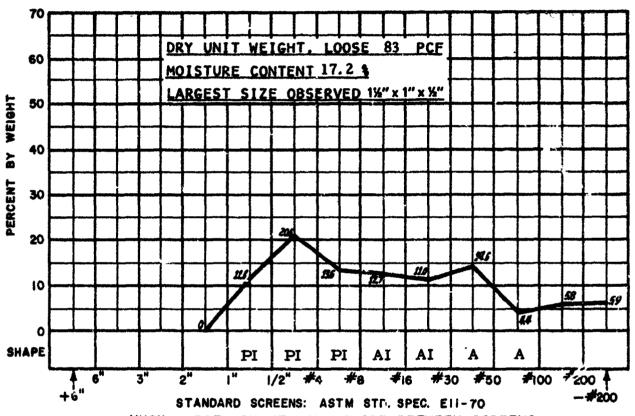
MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 6.9 % Moisture, 390 Angle Slide Steel Plate

@ 6.9 % Moisture, 40°

Apparent Cohesion PSF 7.1 % Moisture, 0 Bulk Density PCF 0.0 % Moisture, 91

Angle/Repose 10" Drop @ 6.9 % Moisture, 340 Angle Internal Friction @ 7.1 % Moisture, 33°



PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Igneous: Granite, fine grained, moderately fractured. High strength. RQD (Est.) 90%. DUW: 160 PCF. Ground water: Minor. Hardness: Schmidt 54.

System Class: TBM, Wirth Erkelenz, Hardrock, with Hughes Tool head, 9' 10" dia. 29 Hughes Tool TCB roller and cone cutters. RPM: 125 K ft # torque, 630 K# thrust. Mucking: Buckets to belt. Haulage: Rail. Support: 4" ring and half sets, roof plates and rock bolts.

MDN STUDY

SYSTEM DATA SHEET

Ident. No. NAST-4

4/1/73

MDN

Sheet 2

Lithology: Igneous, granite, massive, major feldspar and quartz, minor

dark mineral content.

Uniaxial Compressive Strength: 35 KPSI

RQD: (Estimated) 96% Dry Unit Weight: 161 PCF

Ground Water: Minor, through fractures.

Hardness: Schmidt 42.

Youngs Mod.: 6.40 PSI x 10⁶ (Note 2).

Poisson Ratio: 0.30 (Note 2).

TUNNEL DATA:

Size: 10' x 10' Horse shoe. Grade (-) 0.22% Ventilation System: 8 KCFM, exhaust, 22" pipe.

Utility System: 6" air line, 2" water line

Water Inflow: 5-10 gpm.

Power System: 110V. lighting

Haulage System: Muck and supplies: Eimco 912 diesel.

Support System: 4" WF steel sets @ 4' in 180' approx. at portal end; 1" x 7'

grouted rock bolts for approx. 351.

EXCAVATION DATA:

Conventional Trackless System.

Drilling: Crawler Jumbo, 2-D93 Drifters, 10' feeds. Drill Round: 48-1 3/4" holes, double V cut, 8' depth.

Explosives: 175# Gelex #2-70%. Powder factor, 6.1#/CY.

Blasting: Electrical, regular delays, zero through #10. Mucking System: Eimco 912 diesel, front end loader.

Guidance: Transit lines.

NOTE 2: Inferred from D. U. Deere AD646610-1966.

Abrasiveness N. A.

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Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.59

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 16.20% Plasticity Index 0.42% Plastic Limit 15.78 % Toughness Index 0.14 Shrinkage Limit 13.67%, Flow Index 3.00

MATERIAL SIZE (-) 2.0 IN.

0.0 % Moisture, 106

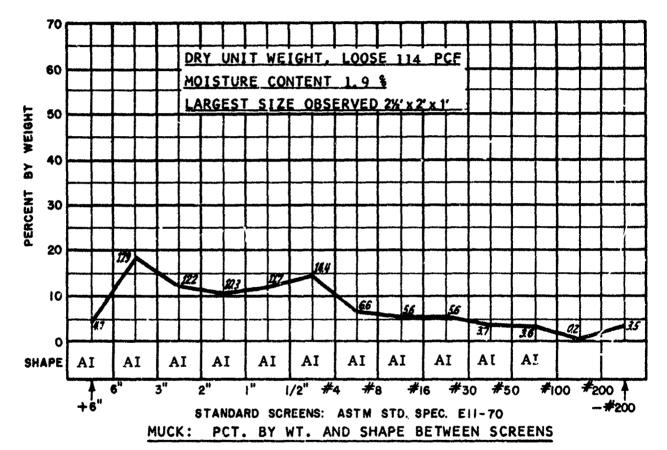
Angle/Repose 1" Drop Ap @ 0.9 % Moisture, 39° @ Angle Slide Steel Plate Bu @ 0.9 % Moisture, 34° @

Apparent Cohesion PSF

© 0.9 % Moisture, 215

Bulk Density PCF

Angle/Repose 10" Drop @ 0.9 % Moisture, 36° Angle Internal Friction @ 0.9 % Moisture, 46°



SUMMARY

Rock Class: Igneous: Granite, massive, minor dark minerals. Very high strength. RQD (Est.) 96%. DUW: 161 PCF. Ground water: Minor. Hardness: Schmidt 42.

System Class: Conventional Trackless. 10' x 10' arch. Two machine jumbo, 48-8' holes, V-cut. PF 6.1 #/CY. Front end loader mucking and haulage. Support: Steel sets at 4', 25%, occasional rock bolts in 730'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. GA-1 Sheet 2

Lithology: Igneous, granite, gray, fine grained, moderately jointed with 1.5' to 2' bands of light tan pegmatite and laminated granite gneiss.

Uniaxial Compressive Strength: 32 KPSI.

RQD: (Estimated) 80%. Dry Unit Weight: 162 PCF.

Ground Water: Formations generally dry.

Hardness: Schmidt 50.

Youngs Mod.: 8.00 PS(x 10⁶ (Note 2).

Poisson Ratio: 0.31 (Note 2).

TUNNEL DATA:

Size: 10' x 10', Modified Horseshoe. Grade: (+) 1/4%

Ventilation: 15 KCFM, exhaust, 26" dia. pipe, 125 HP at 7200' from portal.

Utility System: 8" air line, 4" water line, 10" pump line.

Water Inflow: 20 GPM. (As much as 400 GPM in occasional pockets)

Power System: 4160/440V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage, 75# rail. Three-15T. Goodman locomotives; 2 trains of 11 to 13 cars @ 4.8 CY. Canton car transfer at 50' to 250' from face, passing tracks @1500'.

Support System: 4" WF sets @ 4', 3' and 2' for 23%, 1" x 7' grouted bolts for 17%, Shotcrete: 500 psi @ 18 hrs., 3750 psi @ 28 days, for 16% of 7200'.

EXCAVATION DATA:

Conventional Rail System.

Drilling: Rail mounted hydrojib jumbo, 4-CF99, & 1-CF133 drifters, '2' feed.

Drall Round: 38 holes, 1-5" center hole and 37 at 1 3/4" dia. Spiral Burn Cut, 10 1/2" depth.

Explosives: 183 lbs. Gelex #2-75% x 1-1/2" dia., and 20 lbs. Smoothtex 70% x 7/8" dia. in upper perimeter holes. Powder factor: 5 1/2#/CY.

Blasting: Electrical, regular delays zero through 10.

Mucking: EIMCO #25, rail, air operated.

Guidance: Laser

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. H-1

Sheet 1

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Atrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056":

Spec. Gravity, Material Size(-)0.75" : 2.70

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.0%

Plastic Limit 17.0 % Plasticity Index 1.0 % Toughness Index 0.23 Shrinkage Limit 13.4 % Flow Index 4.4

MATERIAL SIZE (-) 2.0 IN.

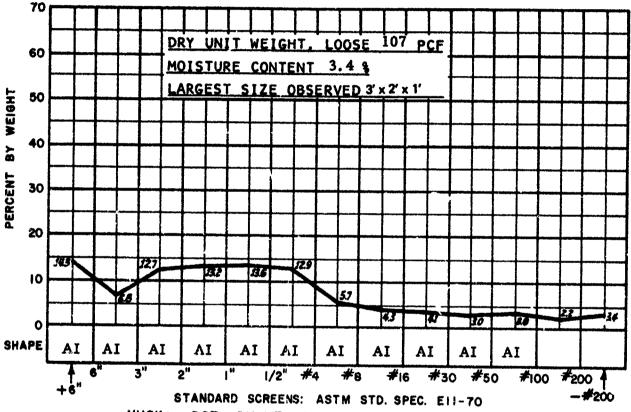
Angle/Repose 1" Drop 1.3 % Moisture, 40° Angle Slide Steel Plate

Apparent Cohesion PSF 2.2% Moisture, 780 Angle/Repose 10" Drop 1.3 % Moisture, 370 Angle Internal Friction

1.3 % Moisture: 32°

Bulk Density PCF

0.0% Moisture, 103.48 @ 2.2 % Moisture, 44°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Igneous: Granite, fine grained, with 1.5' to 2' bands of pegmatite and laminated granite gneiss. High strength. RQD (Est.) 80%. DUW: 162 PCF. Ground water: Minor. Hardness: Schmidt 50.

System Class: Conventional Rail. 10' x 10' arch. Five machine jumbo, 38 10-1/2' holes, burn cut. PF 5.5#/CY. Overhead loader mucking, rail haulage. Support: Steel sets at 2' to 4', 23%, rock bolts 17%, shotcrete 16%, in 7200'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN 2

Ident. No. H-1 Sheet 2

Lithology: Igneous, granite, gray, gneissic, moderately jointed.

Uniaxial Compressive Strength: 39 KPSI

RQD: (Estimated) 80% Dry Unit Weight: 164 PCF

Ground Water: Generally dry - occasional flows through fractures

Hardness: Schmidt 57 (Note 2).

Youngs Mod.: 7.50 PSI x 10⁶ (Note 2).

Poisson Ratio: 0.32 (Note 2)

TUNNEL DATA:

Size: 10' x 10' modified horseshoe. Grade: (+) 1/4%

Ventilation System: 8 KCFM exhaust, 26" pipe, 150 HP at 10,000 from portal.

Utility System: 8" air line, 4" water line, 10" pump line

Water Inflow: 20-400 GPM, normal 135 GPM

Power System: 4160/480/240V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage, 75# rail. Three-15T. Goodman locomotives, 3 trains of 5 to 7 cars @ 4.8 cy. Canton car transfers at 50' to 250' from face, passing tracks @ 1500' to 2500'.

Support System: Minor rock bolt support for last 2500'.

EXCAVATION DATA:

Conventional Rail System

Drilling: 4 boom Hydojib jumbs, 4-CF99 + 1-CF133 drifters, 12' contin. feed.

Drill Round: 36-40 holes, 1 3/4" diameter, 11' deep, spiral burn cut with 5" center hole.

Explosives: 200 lbs. 75% Gelex #2, 25 lbs. 30% Dupont 7/8" x 24" in back holes.

Blasting: Electrical, regular delays 0-10, Powder factor 5.5#/CY.

Mucking: EIMCO #25, rail, air operated

Guidance: Laser

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. H-2 Sheet 1 ; ;

The transfer of the second
Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056":

Spec. Gravity, Material Size (-) 0.75" : 2.60

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.10%

Plastic Limit 17.95% Plasticity Index 0.15 % Toughness Index 0.04 Shrinkage Limit 11.00 % Flow Index 3.20

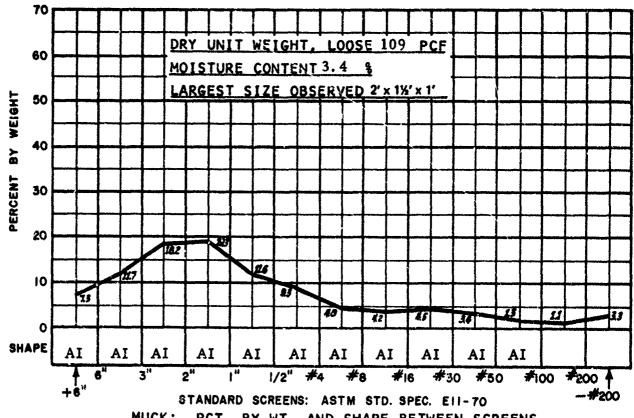
MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 3.8 % Moisture, 300 Angle Slide Steel Plate 3.8 % Moisture, 38°

Apparent Cohesion PSF @ 2.6 % Moisture, 30 **Bulk Density PCF**

@ 0.0 % Moisture, 105

Angle/Repose 10" Drop @ 3.8 % Moisture, 350 Angle Internal Friction @ 2.6 % Moisture, 440



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Igneous: Granite, gneissic, moderately jointed. Very high strengtl RQD (Est.) 80%. DUW: 164 PCF. Ground water: Minor. Hardness: Schmidt 57.

System Class: Conventional Rail. 10' x 10' arch. Five machine jumbo, 36 to 40 - 11' holes, burn cut. PF 5.5#/CY. Overhead loader mucking - rail haulage. Support: occasional rock bolts 7200' to 10,000'.

MDN STUDY

SYSTEM DATA SHEET

Ident. No. H-2

4/1/73

MDN

Sheet 2

Lithology: Igneous, granite gneiss, moderately jointed, with three intersecting sets of fractures dipping 45° to vertical at 4" to 2".

Uniaxial Compressive Strength: 29 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 162 PCF.

Ground Water. Minor to moderate in fractures.

Hardness: Schmidt 46

Youngs Mod.: 5.89 PSI x 106

Poisson Ratio: 0 31

TUNNEL DATA:

Size: 10' x 10' modified horzeshoe. Grade: (1) 1/4%.

Ventilation System: 6 KCFM exhausi, 26" pipe, 220 HP at 22,000' from portal.

Utility System: 10" air line, 4" water line, 12" pump line.

Water Inflow: 400 GPM, total, 2-3 GPM from breast.

Power System: 4160/480/240V.

Haulage System: Muck, personnel, supplies by rail cars, 36" gage, 75# rail. Three-15T. Goodman locomotives, 3 trains of 13 cars @ 4.8 cy. Canton car transfers at 50' to 250' from face, passing tracks @ 2700' to 3600'. Support System: 1" x 7' grouted bolts in current use. Total: rock bolts

9%, 3" to 4" shotcrete 36%, 4" WF steel sets 10%.

EXCAVATION DATA:

Conventional Rail System

Drilling: 4 boom Hydojib jumbo, 4-CF93 + 1-PR123 drifters, 12' contin. feed.

Drill Round: 40 hotes, 1 3/4" diameter, 11' deep, spiral burn out with 5" center hole.

Explosives: 200 lbs. 75% Gelex #2, and 25 lbs., 30% 7/8" x 24" in back holes.

Blasting: Electrical, regular delays 0-10, Powder factor 5.8#/CY.

Mucking: EIMCO #2^r, rail, air operated.

Guidance: Laser.

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.497

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 17.20% Plasticity Index 0.40% Plastic Limit 16.80% Toughness Index 0.11 Shrinkage Limit 16.65% Flow Index 3.80

MATERIAL SIZE (-) 2.00IN.

Angle/Repose 1" Drop

Apparei t Cohesion PSF

Angle/Repose 10" Drop

4.46% Moisture, 38.50°@ Angle Slide Steel Flate

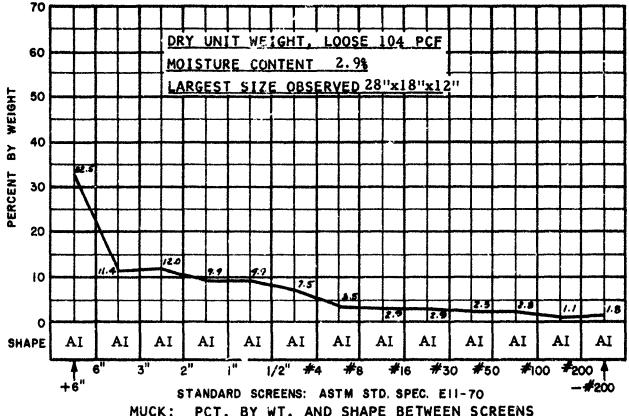
4.40% Moisture, 0 Bulk Density PCF

4.46% Moisture, 35.35°

Angle Internal Friction

4.46% Moisture, 31.500@ 4.46% Moisture, 98.9

4.46% Moisture, 43.50°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Igneous: Granite gneiss, moderately jointed with intersecting fractures dipping 45° to vertical at 4" to 2', 1-1/2' average. High Strength. RQD (Est.) 90%. DUW: 162 PCF. Ground water: Minor to moderate.

Hardness: Schmidt 46.

System Class: Conventional Rail. 10' x 10' arch. 5 machine jumbo, 40-11' holes, burn cut w/5" center hole. PF 4.75#/CY. Overhead loader muckingrail haulage. Support: Grouted rock bolts as required.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. H-3 Sheet 2

Lithology: Igneous, biotitic quartz monzonite, fine to medium grained porphyry.

Uniaxial Compressive Strength: 25 KPSI

RQD: (Estimated) 83%

Dry Unit Weight: 162 PCF.

Ground Water: None apparent

Hardness: Schmidt 53.

Youngs Mod.: 8.80 PSI x 10⁶ (Note 2).

Poisson Ratio: 0.30 (Note 2).

TUNNEL DATA:

Size: 18' wide x 16' high, arched back. Grade: (+) 5 1/2%.

Ventilation System: 76 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HP, 2 stage, surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220V for fans, 110 volt lighting.

Haulage System: Wagner ST8 Scooptram to raise, chute loaded into rail

mounted skip. Personnel and supplies by diesel truck.

Support System: 13 1/2" x 9' roof plates, 6' x 3/4" rock bolts @ 4'.

EXCAVATION DATA:

Conventional Trackless System

Drilling: Gardner-Denver 3 boom jumbo, 1 PR123 and 2 DH 123 drifters, 12' feeds.

Drill Round: 47 holes, 1 3/4" diameter, including 6 hole burn cut, and 1 center hole, 4" diameter, all 10 1/21 deep.

Explosives: 25# - 11/2" x 8", 60% or 75% primers, 25# - 7/8" x 16", 30% in trim holes, 40# - 11/2" x 16", 45% in 6 hole burn cut, and 275# AN/FO in remainder of round. Powder factor: 4#/cy.

Blasting: Electrical, regular delays, 0 through 15.

Mucking: Scooptram.

Guidance: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident, No. LK-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size(-)0.75": 2.85

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.10% Plasticity Index 0.12%

Plastic Limit 17.98% Toughness Index 0.30

Shrinkage Limit 17.69% Flow Index 3.90

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop

© 0.8 % Moisture, 33°

Angle Slide Steel Plate

© 0.8 % Moisture, 29°

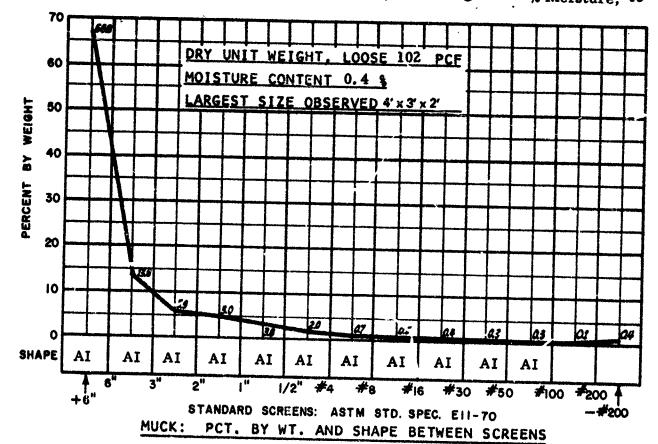
Apparent Cohesion PSF @ 0.4 % Moisture, 435 Bulk Density PCF @ 0.0 % Moisture, 97.3

Angle/Repose 10" Drop

@ 0.8 % Moisture, 300

Angle Internal Friction

@ 0.4 % Moisture, 430



SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry. High strength. RQD (Est.) 83%. DUW: 162 PCF. Ground Water: Dry. Hardness: Schmidt 53.

System Class: Conventional Trackless. 18' wide x 16' arch. Three boom jumbo, 47-10 1/2' holes, burn cut. PF 4#/CY. Scooptram mucking and haulage to raiserail skip to surface. Support: Roof plates and rock bolts at 4'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-1 Sheet 2

Lithology: Igneous, biotitic quartz monzonite, fine to medium grained porphyry, with minor steeply inclined joints.

Uniaxial Compressive Strength: 28 KPSI

RQD: (Estimated) 83%
Dry Unit Weight: 165 PCF
Ground Water: None apparent
Hardness: Schmidt 56 (Note 2).

Youngs Mod.: 9.40 PSI x 106 (Note 2).

Poisson Ratio: 0.33 (Note 2).

TUNNEL DATA:

Size: 18' wide x 16' high, arched back. Grade: (+) 2%.

Ventilation System: 22 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HP, 2 stage surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220 for pumps and fans, 110V lighting.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station, rail mounted skip to surface. Personnel and supplies by diesel truck. Support System: 13 1/2" x 9" roof plates, 6" x 3/4" rock bolts @ 4".

EXCAVATION DATA:

Conventional Trackless system.

Drilling: Gardner-Denver 3 boom jumbo, 3 PR123 drifters, 121 feeds.

Drill Round: 47 holes, 1 3/4" diameter, including 6 hole burn cut, and 1 center hole, 4" diameter, all 10 1/2' deep.

Explosives: 25#-1 1/2" x 8", 60% or 75% primers, 25#-7/8" x 16", 30% in trim holes, 40#-1 1/2" x 16", 45% in 6 hole burn cut, and 275# AN/FO in remainder of round. Powder factor: 4#/CY.

Blasting: Electrical, regular delays, 0 through 15.

Mucking: Scooptram. Guidance: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056":

Spec. Gravity, Material Size (-) 0.75": 2.73

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 20.50%

Plastic Limit 19.14% Plasticity Index 0.36 % Toughness Index 0.058 Shrinkage Limit 17.29 %

Flow Index 6.2

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 4.7 % Moisture, 43° Angle Slide Steel Plate

Apparent Cohesion PSF 4.9 % Moisture, 210 Bulk Density PCF

Angle/Repose 10" Drop @ 4.7 % Moisture, 42° Angle Internal Friction @ 4.9 % Moisture, 39°

4.7 % Moisture, 330

0.0 % Moisture, 97.6

DRY UNIT WEIGHT, LOOSE 103 PCF 60 MOISTURE CONTENT 1.6 % LARGEST SIZE OBSERVED 3%' x 2' x 2' WEIGHT 50 40 87 PERCENT 30 20 10 0 SHAPE ΑI ΑI ΑI ΑI ΑI ΑI ΑI ΑI AI ΑI ΑI 1/2" #4 #8 #16 #30 #50 #100 #200 P #200 STANDARD SCREENS: ASTM STD. SPEC, E11-70

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry, minor steep angle joints. High strength. RQD (Est.) 83%. DUW: 165 PCF. Ground water: Dry. Hardness: Schmidt 56.

System Class: Conventional Trackless. 18' wide x 16' arch. Three boom jumbo. 47 - 10 1/2' holes, burn cut. PF 4#/CY. Scooptram mucking and haulage, rail skip to surface. Support. Roof plates and rock bolts at 41.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-2 Sheet 2

Lithology: Igneous, biotitic quartz monzonite, fine to medium grained porphyry.

Uniaxial Compressive Strength: 32 KPSI

RQD: (Estimated) 92% Dry Unit Weight: 165 PCF

Ground Water: None apparent.

Hardness: Schmidt 54.

Youngs Mod.: $9.00 \text{ PSI} \times 10^6 \text{ (Note 2)}$.

Poisson Ratio: 0.32 (Note 2).

TUNNEL DATA:

Size: 12' diameter vertical bore hole, reamed from 1312' to 1212' below collar, from a 13 7/8" diameter pilot hole.

Ventilation System: None in bore hole.

Utility System: 5 to 10 gpm. Water for dust suppression through pilot hole.

Water Inflow: None apparent

Power System: 440V to surface drive motors.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/

rail mounted skip to surface.

Support System: None in bore hole.

EXCAVATION DATA:

Machine: Robbins H81R Raise Drill. Weight 49 tons. Cutters: 27 Robbins, Steel Disc. Gage: 3-12". Center: 1-11". Interior: 19-12" single and 2-11" twin. Two sets of three 12" dia. TCB roller stabilizers are installed on third points below the cutter head.

Rotation, cutter head: 6 RPM.

Torque: 260 K Foot Lbs. Full Load.

Reaming Pull: Total 814K Lbs @ 2400 PSI, net 507 K#.

Muck Disposal: Scooptram, underground.

Power System: 3-440V, 100 HP motors, 1.667: 1 gathering

box ratio.

Guidance System: Survey in pilot hole.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. LK-5 Sheet 1

MDN

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

N. A. Size (-)0.056": Size(-)u. 056": 2.67

ATTERBERG LIMITS, MATERIAL SIZE (-) 0. 056 IN.

Liquid Limit 25.00 %

Plastic Limit 20.95 % Plasticity Index 4.05 % Toughness Index 0.73 Shrinkage Limit 19.68 % Flow Index 5.50

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop % Moisture, 33° @ 3.0 @ 3.4

Angle Slide Steel Plate

Apparent Cohesion PSF % Moisture, 75 **Bulk Density PCF**

Angle/Repose 10" Drop @ 3.4 % Moisture, 320 Angle Internal Friction @ 3.0 % Moisture, 37°

% Moisture, 38° @ 3.4

@ 0.0 % Moisture, 100

70 DRY UNIT WEIGHT. LOOSE 94 PCF 60 MOISTURE CONTENT 16.8 \$ LARGEST SIZE OBSERVED 25" x 4" x 5" BY WEIGHT 50 40 PERCENT 30 20 10 SHAPE PI PI PE A #30 #50 1/2" #4 #8 **≠**100 #16 - #200 STANDARD SCREENS: ASTM STD. SPEC. E11-70

> MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry. High strength. RQD (Est.) 92%, DUW: 165 PCF. Ground water: Dry. Hardness: Schmidt 54.

System Class: RBM, Robbins H81R, 12' dia. 27 Robbins disc cutters, 6 RPM, 383.5 Kft. # torque, 408 K# pull average. Mucking and haulage: Scooptram underground, rail skip to surface. Support None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-5 Sheet 2

Lithology: Igneous, bioticic quartz monzonite, fine to medium grained porphyry, frequent flat angled joints.

Uniaxial Compressive Strength: 3 KPSI (One Spec., L/R = 1.3).

RQD: (Estimated) 86%.

Dry Unit Weight: 137 PCF.

Ground Water: None apparent.

Hardness: Schmidt 20 (Note 3).

Youngs Mod.: 1.50 PSI x 106 (Note 2).

Poisson Ratio: 0.20 (Note 2).

TUNNEL DATA:

Size: 4' diameter vertical bore hole reamed from 298' to 286' below collar from a 13 7/8" diameter pilot hole.

Ventilation System: Not applicable.

Utility System: 5 to 10 gpm water for dust suppression through pilot hole.

Water Inflow: None apparent.

Power System: 440V to surface drive motors.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail mounted skip to surface. Personnel and supplies by diesel truck.

Support System: None in bore hole.

EXCAVATION DATA:

Machine: Robbins H81R Raise Drill. Weight: 49 tons.

Cutters: 11-Robbins, Steel Disc. Gage: 1-12" twin. Center 1-12" single. Interior: 4-12" twin. Three 12" TCB roller stabilizers are installed at third points below the cutter head.

Rotation, Cutter head: 6 RPM

Torque: 260 K Foot/lbs. Full Load

Reaming Pull: Net 207K#

Muck Disposal: Scooptram underground.

Power System: 3-440V, 100 HP motors, 1.667: 1 gathering

box ratio.

Guidance System: Survey in pilot hole.

NOTE 2: Inferred from D. U. Deer: AD 646610-1966.

NOTE 3: Test of Unpolished Specimen.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-6 Sheet 1

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Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056":

Spec. Gravity, Material Size (-)0. 75" : 2. 53

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 19, 40 %

Plastic Limit 18, 16 % Plasticity Index 1,24 % Toughness Index 0.31.

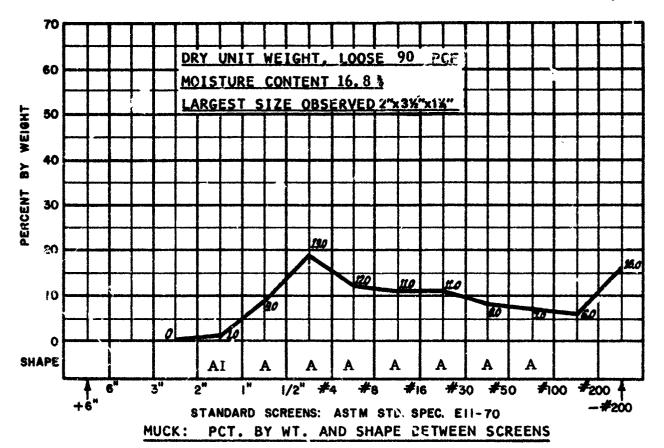
Shrinkage Limit 17.27 % Flow Index 4,00

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop Angle Slide Steel Plate @ 3.7 % Moisture, 32° @ 0.0 % Moisture, 101

Apparent Cohesion PSF @ 3.7 % Moisture, 30° @ 0.2 % Moisture, 0 **Bulk Density PCF**

Angle/Repose 10" Drop @ 3.7 % Moisture, 290 Angle Internal Friction @ 0.2 % Moisture, 40°



SUMMARY

Rock Class: Igneous: Quartz monzonite, biotitic, fine to medium grained porphyry, frequent flat angled joints. Very low strength. RQD (Est.) 86%. DUW: 137 PCF. Ground water: Dry. Hardness: Schmidt 20.

System Class: RBM, Robbins H81R, 4' dia. 11 Robbins disc cutters. 6 RPM, 260 K ft # torque, 198 K # pull (average). Mucking and Haulage: Scooptram underground, rail skip to surface. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-6 Sheet 2

Lithology: Igneous, quartz monzonite porphyry, intensely altered, coarse grained.

Uniaxial Compressive Strength: 7 KPSI.

RQD: (Estimated) 35%.

Dry Unit Weight: 158 PCF

Ground Water: None Hardness: Schmidt 37.

Youngs Mod.: 4.76 PSI x 10⁶.

Poisson Ratio: 0.10.

TUNNEL DATA:

Size: 15' wide x 14' high, arched back. Grade: (-) 26%.

Ventilation System: 22 KCFM, pressure, 48" pipe and tubing, 150 HP @ 650'.

Utility System: 6" air, 2" water, 4" pump line.

Water Inflow: Minor

Power System: 4160/220, 110V lighting.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail

mounted skip to surface. Personnel and supplies by Diesel truck. Support System: 13 1/2" x 9' roof plates, 6' x 3/4" rock bolts at 4'.

EXCAVATION DATA:

ACCUPATION OF THE PROPERTY OF

Conventional Trackless System.

Drilling: Three boom hydrojib jumbo, w/PR123 drifters on 12' feeds.

Drill Round: 42 holes, 1 3/4" diameter, including 6 hole burn cut, and 1-4" diameter center hole, all 10 1/2" deep.

Explosives: 25#-1 1/2" x 8", 60% as primers, 25#-7/8" x 16", 30% in trim holes, 300#-1 1/2" x 16" in remainder of round. Powder factor: 4.7#/CY.

Blasting: Electrical, regular delays 0 through 15.

Mucking System: Scooptram

Guidance: Laser.

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material Size (-) 0.75": 2.68

N. A. Size(-)0.056": 0

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.00% Plasticity Index 0.88 %

Plastic Limit 17.12 % Toughness Index 0.18

Shrinkage Limit 17.04 % Flow Index 5.00

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 1.7 % Moisture, 29° Angle Slide Steel Plate @ 1.7 % Moisture, 28°

Apparent Cohesion PSF

@ 0.2 % Moisture, 70

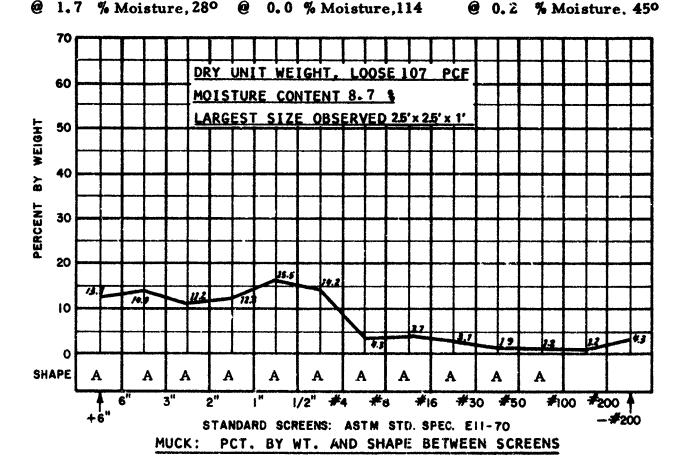
Bulk Density PCF

Angle/Repose 10" Drop

@ 1.7 % Moisture, 26°

Angle Internal Friction

@ 0.2 % Moisture, 45°



SUMMARY

Rock Class: igneous: Quartz monzonite porphyry, intensely altered, course grained. Low strength. RQD (Est.) 85%. DUW: 158 PCF. Ground water: None. Hardness: Schmidt 37.

System Class: Conventional Trackless, 15' wide x 14' arch. Three boom jumbo, 42-10 1/2' holes, burn cut. PF 4.7 #/CY. Scooptram mucking and haulage rail skip to surface. Support: Roof plates and rock bolts at 4'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-7 Sheet 2

Lithology: Igneous, quartz monzonite, coarse grained with many sulfide veinlets, highly fractured, pronounced orthogonal faulting.

Uniaxial Compressive Strength: 19K.

RQD: (Estimated) 50%. Dry Unit Weight: 165 PCF

Ground Water: Saturated below working levels.

Hardness: Schmidt 47.

Youngs Mod.: $7.46 \text{ PSI} \times 10^6$.

Poisson Ratio: 0.20.

TUNNEL DATA:

Size: 12' x 12' Grade: (+) 0.4%

Ventilation System: 14 KCFM, pressure, 24" diameter pipe, 60 HP @ 400'

from airway.

STATE OF THE PROPERTY OF THE P

Utility System: 2" water, 4" airline, 8" pump line.

Water Inflow: None upper levels, 20-200 gpm lower levels.

Power System: 2400/480/240/110.

Haulage System: Muck, supplies, personnel by railcars, 8 ton battery locomotives, 10 ton bottom dump devel. cars, 36" gage, 45# rail.

Support System: 10 1/2' x 12" x 12" wood posts, 12" H beam cap sets at 5'

centers in normal ground.

EXCAVATION DATA:

Conventional Rail System.

Drilling: 3 boom hydrojib jumbo, CF79 drifters on 6' shells or D89 drifters on 6' chain feeds.

Drill Round: 52 holes, 1 5/8" diameter, including 2 hole wedge burn and 4 relievers, 5' depth.

Explosives: 100# Carbamite per round (Amogel in wet ground).

Blasting: #6 caps, 8' fuse, timed by order of connection to igniter cord. (Primacord used in place of primer powder) Powder factor 3.8#/CY.

Mucking System: Eimco 40 loader.

Guidance: Transit survey.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident No. SM-1

Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size(-) 0.056": 0

Spec. Gravity, Material Size(-)0.75": 2.72

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 12.50%

Plasticity Index 1.48 %

Plastic Limit 11.02% Toughness Index 0.29 Shrinkage Limit 10.52 % Flow Index 5.1

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop

@ 0.2 % Moisture, 360

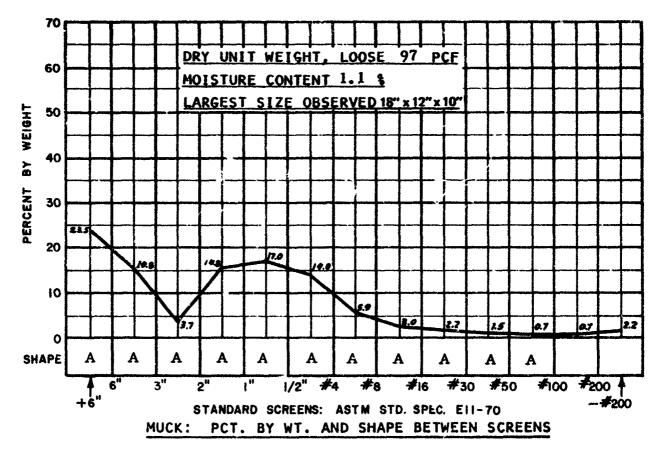
Angle Slide Steel Plate

@ 0.2 % Moisture, 280

Apparent Cohesion PSF @ 0,2 % Moisture, 90 Bulk Density PCF

@ 0.0 % Moisture, 112

Angle/Repose 10" Drop
© 0.2 % Moisture, 31°
Angle Internal Friction
© 0.2 % Moisture, 44°



SUMMARY

Rock Class: Igneous: Quartz monzonite, course grained, many sulfide veinlets. Highly fractured, pronounced orthogonal faulting. High strength. RQD (Est.) 50%. DUW: 165 PCF. Ground water: Dry. Hardness: Schmidt 47.

System Class: Conventional Rail. 12' x 12'. Three boom jumbo, 52-5' holes, wedge cut. PF 3.8#/CY. Eimco 40 mucker. Haulage: Rail. Support: Wood posts and steel cap at 5'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. SM-1 Sheet 2

Lithology: Metamorphic, gr.nitic gneiss, highly metamorphosed, moderately

to highly fractured, highly silicified.

Uniaxial Compressive Strength: 9 KPSI.

RQD: (Estimated) 10%. Dry Unit Weight: 174 PCF'.

Ground Water: Minimal-drains to other workings.

Hardness: Schmidt 30 (Note 3). Youngs Mod.: 9.70 PSI x 10⁶. Poisson Ratio: 0.35 (Note 2)

TUNNEL DATA:

Size: 13', round, Grade (+) 1/4 percent.

Ventilation System: 10 K CFM. exhaust, 24" pipe

Utility System: 4" air line, 2" water line.

Water Inflow: 5-10 gpm. Power System: 4160/480V.

Haulage System: Personnel, muck, supplies by rail cars.

Support System: None.

EXCAVATION DATA:

Machine: Calweld, Hardrock model, #40.

Weight: 200 tons.

Cutters: 19-Smith Tool Tungsten Carbide Button, Gage: 6-GT-SH 8 roller.

Center: 1-TCB 24" tricone, interior: 12-GT-MH8 roller.

Rotation: Lenter cutter-26 RPM, Head-12 RPM.

Torque: 347 K # max.

Thrust: 1,128 K #. 677 K# operating

Muck Collection: Buckets from face, 24" conveyor to rear.

Power System: 480V Electro-Hydraulic, 825 HP.

Guidance System: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

NOTE 3: Test of Unpolished Specimen.

N

Abrasiveness N. A.

Pot. Vol. Change, Material Size : NA

Spec. Gravity, Material
Size : NA

ATTERBERG LIMITS, MATERIAL SIZE

IN.

Liquid Limit NA %
Plasticity Index NA %

Plastic Limit NA %
Toughness Index NA

Shrinkage Limit NA % Flow Index NA

MATERIAL SIZE

IN.

Angle/Repose 1" Drop

Moisture, NA

Angle Slide Steel Plate

Apparent Cohesion PSF

Moisture, NA

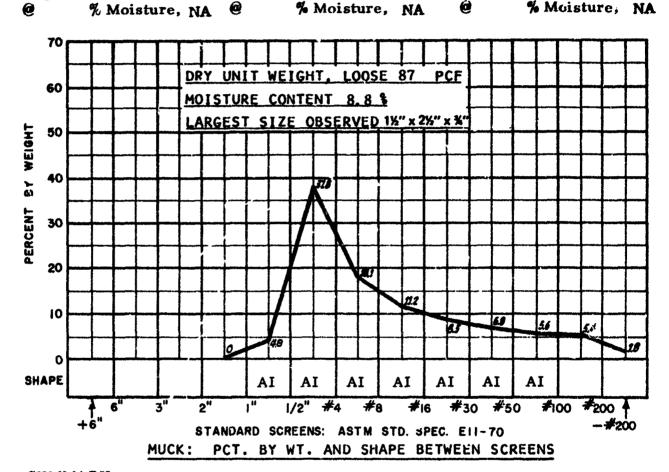
Bulk Density PCF

Angle/Repose 10" Drop

Moisture, NA

Angle Internal Friction

Moisture, NA



SUMMARY

Rock Class: Metamorphic: Granitic gneiss, highly metamorphosed and silicified, moderately to highly fractured. RQD: (Est.) 10%. DUW: 174 PCF. Medium strength. Ground water: Dry. Hardness: Schmidt 30.

System Class: TBM, Calweld #40, 13' dia. 19 Smith Tool TCB roller and tricone cutters. RPM: Head 12, center 26. 347K ft # torque, 677 K# thrust.

Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MON

Ident. No. CL-1 Sheet 2

Lithology: Metamorphic, interlayered transition between quartzite and tactite. Moderately to strongly altered metasediments, with replacement pyrite, chalcopyrite and magnetite, and a high percentage of silicates, very fine to medium grained.

Uniaxial Compressive Strength: 26 KPSI.

RQD: (Estimated) 80% Dry Unit Weight: 178 PCF. Ground Water: None apparent

Hardness: Schmidt 50.

Youngs Mod.: 11.20 PSI x 10⁶ (Note 2).

Poisson Ratio: 0.34 (Note 2).

TUNNEL DATA:

Size: 16' wide x 14 1/2' high, arched back. Grade: (+) 2%.

Ventilation System: 52 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HP, 2 stage surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220V for pumps and fans, 110V lighting

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail

mounted skip to surface. Personnel and supplies by diesel truck. Support System: 13 1/2" x 9' roof plates, 6' x 3/4" rock bolts at 4'.

EXCAVATION DATA:

Conventional Trackless System.

Drilling: Gardner-Denver 3 boom jumbo, 3 PR123 drifters, 12' feeds.

Drill Round: 42 holes, 1 3/4" diameter, including 6 hole burn cut, and 1 center hole, 4" diameter, all 6' deep.

Expressives: $15\# - 1\ 1/2" \times 8"$, 60% or 75% as primes $15\# - 7/8" \times 16"$, 30% in trim holes, $25\# - 1\ 1/2" \times 16"$, 45% in 6 hole burn cut, 150# AN/FO in remainder of round. Powder factor 5#/cy.

Blasting: Electrical, regular delays, 0 through 15.

Mucking: Scooptram.

Guidance: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. LK-3

Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0. 056" ;

Spec. Gravity, Material Size (-) 0. 75": 3.21

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.25% Plasticity Index 0.33 %

Plastic Limit 17. 92 % Toughness index 0.06

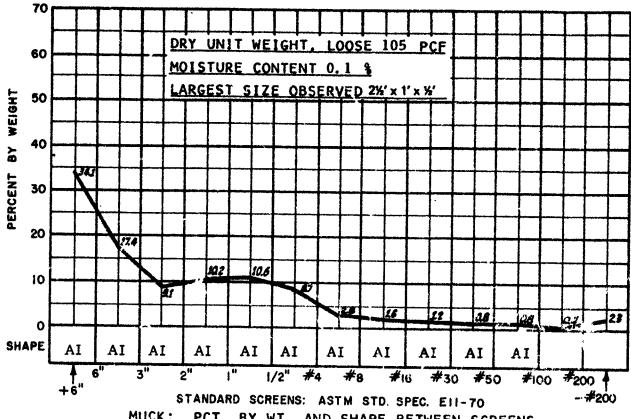
Shrinkage Limit 17.80 % Flow Index 5.50

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 1.5 % Moisture, 30° Angle Slide Steel Plate

Apparent Cohesion PSF @ 0.4 % Moisture, 175 Bulk Density PCF @ 1.5 % Moisture, 29° @ 0.0 % Moisture, 117.8

Angle/Repose 10" Drop @ 1.5 % Moisture. Angle Internal Friction @ 0.4 % Moisture.



PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Quartzite-tactite transition, very fine to medium grained, with replacement sulphides and magnetite, high in silicates. High strength. RQD: (Est.) 80%. DUW: 178 PCF Ground water: Dry.

Hardness: Schmidt 50.

System Class: Conventional Trackless. 16' wide x 14-1/2' arch. Three boom jumbo, 42-61 holes, burn cut. PF 5#/CY. Scooptram mucking and haulage, rail skip to surface Support: Roof plates and rock bolts at 41.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Cim. No. LK-3 Sheet 2

Lithology: Metamorphic, tactite, strongly altered calcareous metasediments, with replacement pyrite, chalcopyrite and magnetite, and a high percentage of silicates, fine to very fine grained.

Uniaxial Compressive Strength: 14 KPSI (One Spec., L/R = 1.3).

RQD: (Estimated) 70%

Dry Unit Weight: 182 PCF

Ground Water: None apparent.

Hardness: Schmidt 33.

Youngs Mod.: $6.50 \text{ PSI} \times 10^6 \text{ (Note 2)}$.

Poisson Ratio: 0.30 (Note 2).

TUNNEL DATA:

Size: 15' wide x 14' high, arched back. Grade: (+) 2%.

Ventilation System: 50 KCFM, pressure in heading, 48" pipe and tubing. Underground fans 48", 150 HP, 2 stage. Exhaust in return airway to 3-54", 150 HP, 2 stage surface fans.

Utility System: 6" compressed air, 2" water.

Water Inflow: None apparent.

Power System: 4160/220V for pumps and fans, 110V lighting.

Haulage System: Wagner ST-8 Scooptram to surge pile at shaft station/rail

mounted skip to surface. Personnel and supplies by diesel truck.

Support System: 6" WF Steel Sets at 5'.

EXCAVATION DATA:

Conventional Trackless System.

Drilling: Gardner-Denver 3 boom jumbo, 3 PR123 drifters, 12' feeds.

Drill Round: 42 holes, 1 3/4" diameter, including 6 hole burn cut and 1 center hole, 4" diameter; all 6' deep.

Explosives: 15#-1 1/2" x 8", 60% or 75% as primers, 15#-7/8" x 16' 30% in trim holes, 25#-1 1/2" x 16", 45% in 6 hole burn cut, 150# AN/FO in remainder of round. Powder factor 5.5#/CY.

Blasting: Electrical, regular delays, 0 through 15

Mucking: Scooptram.

Guidance: Laser

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MIN STUDY 4/1/73

SYSTEM DATA SHEET
MDN

Ident. No. LK-4

Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0. 056": 0

Spec. Gravity, Material Size (-) 0.75": 3.36

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 19.00% Plasticity Index 1.05 %

Plastic Limit 17.95 % Toughness Index 0.19 Shrinkage Limit 16.43 % Flow Index 5.40

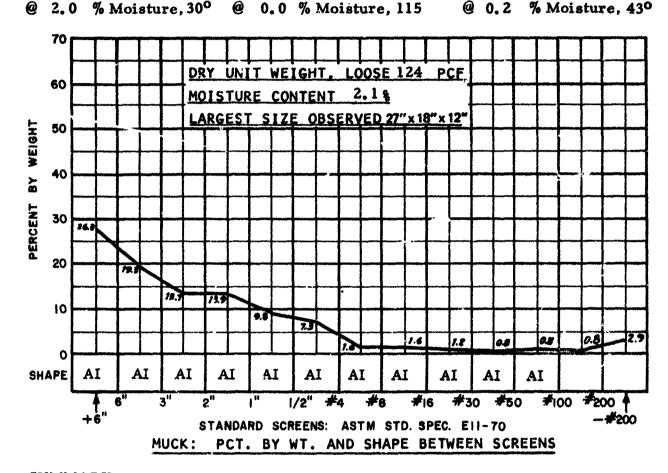
MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 2.0 % Moisture, 370 Angle Slide Steel Plate @ 2.0 % Moisture, 300 Apparent Cohesion PSF

© 0.2 % Moisture, 165

Bulk Density PCF

Angle/Repose 10" Drop @ 2.0 % Moisture, 350
Angle Internal Friction
@ 0.2 % Moisture, 430



SUMMARY

Rock Class: Metamorphic: Tactite, fine to very fine grained, with replacement sulphides and magnetite, high in silicates. Medium strength.

RQD (Est.) 70%. DUW: 182 PCF. Ground water: Dry. Hardness: Schmidt 33.

System Class: Conventional Trackless. 15' wide x 14' arch. Three boom jumbo, 42-6' holes, burn cut. PF 5.5#/CY. Scooptram mucking and haulage, rail skip to surface. Support. Steel sets at 5'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LK-4 Sheet 2

Lithology: Metamorphic, interlayered bands of hematite and martite, highly jointed, normally flat lying, but often highly folded. Natural iron over 60%, silica 5%.

Uniaxial Compressive Strength: 7 KPSI.

RQD: (Estimated) 10% Dry Unit Weight: 207 PCF

Ground Water: Formation generally dry.

Hardness: Schmidt 20 (Note 3).

Youngs Mod.: $2.50 \text{ PSI} \times 10^6 \text{ (Note 4)}$.

Poisson Ratio: 0.15 (Note 4).

TUNNEL DATA:

9'-11 1/2" diameter; normal grade: 0%.

Ventilation System: 3 KCFM, pressure, 8" dia. tube, 5 HP @ 250' from main level.

Utilities: 2" air line, 1" water line, 2-1 1/2" pressure and 1-3" return hydraulic lines.

Water Inflow: None

Power System: 110V lighting, 440V to scraper hoist.

Muck Haulage: 30 HP hoist, and 42" scraper to raise, all rail on main level.

Personnel, rail and ladders supplies by rail cars and hoist.

Support: Continuous; 9'-6" dia. x 4" WF sets at 45".

EXCAVATION DATA:

Machine: Calweld Oscillator. Wt: 69 K#.

Cutters: 278 Carboloy drag bits. Gage: 20 rippers (experimental).

Interior: 258 "J" tools.

Rotation: 8 RPM

Torque: 1200 K ft. #.

Thrust: 300 K# max., 285 K# operating.

Anchorage: Thrust on installed sets, 285K# operating.

Muck Collection: Flight conveyor to rear of machine, removal by scraper.

Power System: Remote power unit; 2-90 gpm, 2500 psi hvdraulic pumps and 125 HP motors on main level; thrust and rotation through hydraulic cylinders.

Guidance System: Survey.

NOTE 3: Test of Unpolished Specimene

NOTE 4; Inferred from Tests of Similar Specimens.

MDN STUDY

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SYSTEM DATA SHEET

Ident. No. MB-1

4/1/73 MDN

Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size (-) 0.75": 4.34

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 17.8 %
Plasticity Index 2.7 %

Plastic Limit 15.1 % Toughness Index 0.66 Shrinkage Limit 13.9 % Flow Index 4.1

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 6.2 % Moisture, 37° Angle Slide Steel Plate @ 6.2 % Moisture, 31° Apparent Cohesion PSF

@ 6.9 % Moisture, 235

Bulk Density PCF

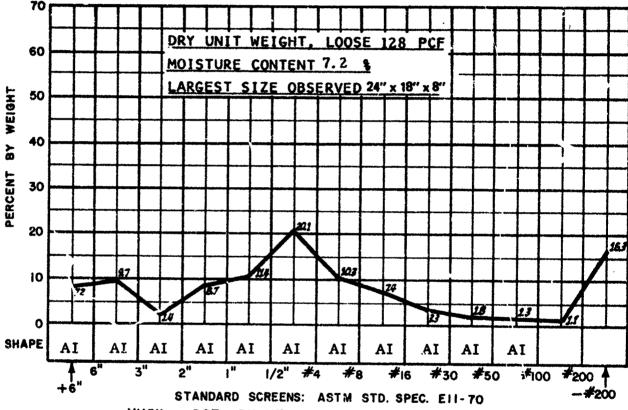
@ 0.0 % Moisture, 141

Angle/Repose 10" Drop

6.2 % Moisture, 35°

Angle Internal Friction

6.9 % Moisture, 35°



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NUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Hematite and martite interlayered, highly jointed, bedding normally flat, often highly folded. Low strength. RQD (Est.) 10%. DUW: 207 PCF. Ground water: Dry. Harding 3: Schmidt 20.

System Class: TBM, oscillator, Calweld #53, 9'11 1/2" dia. 278 Carpoloy drag bits. 8 RPM, 1200 K ft# torque, 285 K# thrust. Mucking: Flight conveyor and scraper to raise. Haulage: Rail. Support: Continuous, 9'6" dia. x 4" H sets at 45".

MDN 5TUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MB-1 Sheet 2

Lithology: Metamorphic, interlayered hematite and martite, highly jointed, normally flat lying, often highly folded. Natural iron over 60%, silica 5%.

Uniaxial Compressive Strength: 6 KPSI.

RQD: (Estimated) 10%.
Dry Unit Weight: 188 PCF

Ground Water: None Hardness: Schmidt 16.

Youngs Mod.: 2.10 PSI x 10⁶

Poisson Ratio: 0.15

TUNNEL DATA:

Size: 10' wide x 9'-6" (7' cap and 8' post). Grade: Level

Ventilation System: 4 KCFM pressure, 8" diameter pipe and tubing, 15 HP @

600', and 8" exhaust, 5 HP @ 100'. Utility System: 2" airline, 1" water line

Water Inflow: None

Power System: 2300/440V.

Haulage System Muck, 30 HP hoist and 48" scraper from surge pile at rear of miner to chute - 160 CF cars, 30 ton tandem locomotives on 30" gage 60# rail to shaft pocket, 14 ton skips to surface.

Support System: 8"-58# WF sets, 7' cap, 8' post, at 4'-5", wood lagging and pipe spiling, 8-1" diameter or 6-2" diameter in back.

EXCAVATION DATA:

Machine: Alpine, Model F-6A Total Weight: 11 tons.

Cutters: 68 Kennametal 43 KH carbide tipped "plumb bob" type, mounted on twin ripper heads at 90° to boom.

Rotation: 60 RPM about horizontal axis; boom moved vertically and horizontally by hydraulic cylinders.

Torque: 49.6 HP.

Thrust: Sumping thrust from 2-10 HP crawler motors.

Anchor Pressure: Crawlers only.

Muck Collection: Central 14" flight conveyor fed by two gathering arms on inclined apron, discharging to surge pile.

Power System: 440V. Guidance: Transit lines.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident No. MB-3 Sheet 1 MUCK DATA Test Data

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)9.056": 0

Spec. Gravity, Material Size (-)0.75": 4.31

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 21.50% Plasticity Index 0.64%

Plastic Limit 20.86% Toughness Index 0.11

Shrinkage Limit 19.00% Flow Index 5.7

MATERIAL SIZE (-)2.0 IN.

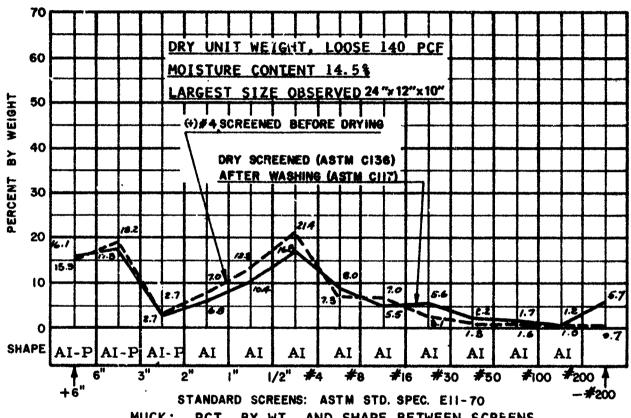
Angle/Repose 1" Drop

Angle Slide Steel Plate

Apparent Cohesion PSF @ 11.56% Moisture, 35.5° @ 11.56% Moisture, 120 **Bulk Density PCF**

Angle/Repose 10" Drop @ 11.56% Moisture, 30.50 Angle Internal Friction

@ 11.56% Moisture, 30.17°@ 11.56% Moisture, 119.64 @ 11.56% Moisture, 37.0°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Hematite and martite interlayered, highly jointed, bedding normally flat, often highly folded. Low strength. RQD (Est.) 10%. DUW: 188 PCF: Ground water: Dry. Hardness: Schmidt 16.

System Class: TBM, Twin head, Alpine F-6A, 10' wide x 9'6" heading. 68 Kennametal T. C. tipped bits. 60 RPM, 49.6 HP head torque, 20 HP sumping thrust. Mucking: Gathering arms, flight conveyor. Haulage: Scraper to rail cars to skip. Support: Steel sets, pipe spiles.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MB-3Sheet 2

2

Lithology: Metamorphic, argillaceous quartzite, medium to thin bedded, moderately to highly folded. Beds high angled to vertical, moderate fracturing sub-parallel to beds and vertical across beds.

Uniaxial Compressive Strength: 21 KPSI. RQD: 75% (Estimated for vertical hole).

Dry Unit Weight: 168 PCF.

Ground Water: None Hardness: Schmidt 45.

Youngs Mod.: $8.35 \text{ PSI} \times 10^6$.

Poisson Ratio: 0.13.

TUNNEL DATA:

Size: 9' W x 10.7', 1 1/2' R. top corner arch. Grade: +1/2%

Ventilation System: 7 KCFM pressure, 24" pipe and tubing, 40 HP at 800'.

Utility System: 4" air line, 2" water line.

Water Inflow: None to minor.

Power System: 2300/480/120 (lighting).

Haulage System: Muck, personnel, supplies by rail cars, 24" gage, 40# rail,

6 ton battery locomotive, 60 CF side dump cars.

Support System: 9' x 13" mats, parallel to centerline, 2 in top and 2 each

rib, 4 3/4" x 6' rock bolts per mat.

EXCAVATION DATA:

Conventional Rail System.

Drilling: 3 boom jumbo, 2-S83F and 1-D99 machines, 8' screw feeds.

Drill Round: 44 holes: 2-4" and 42-1 5/8" diameter, burn cut, 7' depth.

Explosives: 100# Nilite, 25#-60 WR 1" x 16" primers.

Blasting: Electrical, zero and 14 regular delays. Powder Factor: 5.5#/CY.

Mucking System: Atlas-Copco LM56 overhead.

Guidance: Transit lines.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. ST-1 Sheet 1

1

MUCK DATA Test Data

Abrasiveness N. A.

Pot. Vol. Change. Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75: 2.689

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.10% Plasticity Index 2.53%

Plastic Limit 15.57% Toughness Index 0.50

Shrinkage Limit 10.91% Flow Index 5.10

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose 1" Drop 0. 26% Moistuce. 37.15°@

Apparent Cohesion PSF 0.26% Moisture, 740 Angle/Repose 10" Drop 0.26% Moisture, 33.60°

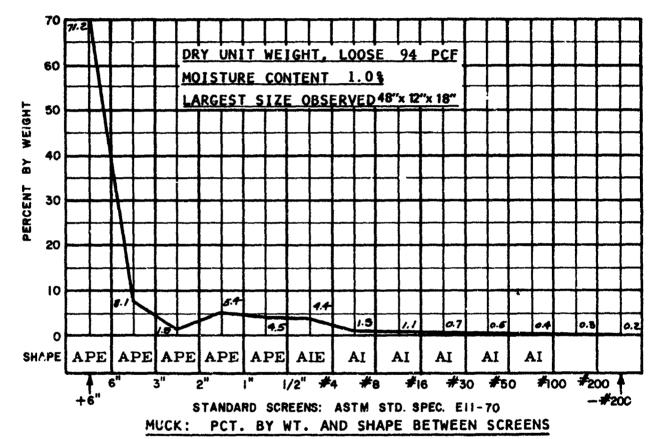
Angle Slide Steel Plate

Bulk Density PCF

Angle Internal Friction

@ 0.26% Moisture, 31.17°@ 0.26% Moisture, 91

0.26% Moisture, 32.7°



SUMMARY

Rock Class: Metamorphic: Argillaceous quartzite, moderately fractured, moderately to highly folded, medium to thin bedded. High strength.

RQD (Est.) 75%. DUW: 168 PCF. Ground water: None. Hardness: Schmidt 45.

System Class: Conventional Rail: 9' x 10'7", 3 boom jumbo, 44-7' holes, burn cut. PF 5.5 #/CY. Mucking: Atlas Copco LM56, Hauage: Rail. Support: Rockbolts and mats.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. ST-1 Sheet 2

Lithology: Metamorphic, quartzite, with minor filled veinlets, thin bedded to massive, moderately folded, moderately to highly fractured/jointed, beds dip 750-900.

Uniaxial Compressive Strength: 13 KPSI,

RQD: (Estimated) Vertical: 50%, horizontal 20-30%.

Dry Unit Weight: 168 PCF.

Ground Water: Minor Hardness: Schmidt 41.

Youngs Mod.: 5.72 PSI x 106

Poisson Ratio: 0.18.

TUNNEL DATA:

Size: 10' x 10' with 1 1/2' top corner radius. Grade: (+) 0.5%.

Ventilation: 13.5 KCFM, pressure, 24" diameter pipe, 80 HP @ 1700' from

cooling unit.

Utility System: 4" air line, 2" water line, 2" pumpline.

Power System: 2300/480/120.

Haulage System: Muck, Eimco 912B-LHD to skip pocket, skips and rail to

surface.

Personnel, Supplies: Rail, cage to level, LHD or Jumbo on level.

Support System: 13" x 9' plates, 5' x 5/8" rock bolts at 3 1/2', plates and rock

bolts on ribs where needed.

Water Inflow: Minor.

EXCAVATION DATA:

Conventional Trackless System.

Drilling: 2 boom hydrojib jumbo, 8' feed, D-93 drifters.

Drill Round: 48 holes, 1 5/8" diameter x 8' V cut.

Explosives: 265#, 250# Nilite, 15# Trojan 60 WR. Powder factor, 9.5#/CY.

Blasting; Electrical, Dupont Acudet 0-14 delay caps.

Mucking: Eimco 912B-LHD.

Guidance: Laser

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. CR-1 Sheet 1

MUCK DATA Test Data

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

Size (-) 0.056": 0 N. A.

Size (-)0.75": 2.714

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 16.50%

Plastic Limit 14.83%

Shrinkage Limit 11.76% Flow Index 4.90

Plasticity Index 1.67% Toughness Index 0.34

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose 1" Drop 0.28% Moisture, 37.6° @

Apparent Cohesion PSF 0.28% Moisture, 400 Angle/Repose 10" Drop 0.28% Moisture, 34.3°

Angle Slide Steel Plate

Bulk Density PCF

Angle Internal Friction 0.28% Moisture, 42.10

0.28% Moisture, 31.75°@

0.28% Moisture, 90

70 DRY UNIT 97 PCF LOOSE 60 MOISTURE CONTENT 1.7% LARGEST SIZE OBSERVED 30"x 14 "x 12" WEIGHT 50 40 ¥ PERCENT 30 20 10 1.0 0.4 0.9 0 SHAPE ΑI ΑI ΑI ΑI ΑI AI ΑI ΑI ΑI AI 1/2" #4 #8 #16 #30 #50 **≠**100 -#200 STANDARD SCREENS: ASTM STD. SPEC. E11-70

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Quartzite minor filled veinlets, moderately to highly fractured/jointed, moderately folded, beds dip 75° to 90°. Medium strength. RQD (Ect.) 50%. DUW: 168 PCF. Hardness: Schmidt 41. Ground Water: Minor.

System Class: Con extional Trackless: 10' x 10', 2 boom jumbo, 48-8' holes, V cut. PF 9.5 #/CY. Mucking: Eimco 912B. Haulage: LHD. Support: Rock bolts and plates.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. CR-1 Sheet 2

Lithology: Metamorphic, phyllite, with vein quartz and chlorite schist,

and the control of the second

highly metamorphosed and folded, with minor faulting.

Uniaxial Compressive Strength: 19 KPSI

RQD: (Estimated) 70% Dry Unit Weight: 187 PCF

Ground Water: Dry Hardness: Schmidt 41.

Youngs Mod.: 8.62 PSI x 10⁶.

Poisson Ratio: 0.20.

TUNNEL DATA:

Size: 7'-6'' wide x 7'-6'' arch.

Ventilation: 7 KCFM, 16" diameter pipe, 30 HP @ 300'. Fan integral with

mechanical cooling unit.

Utility System: 2" water line, 2" airline, 4" water line to cooling unit.

Water Inflow: Minor

Power System: 2400/440/110V.

Haulage System: Muck, supplies, personnel by railcars, 6 and 8 ton

locomotives i 1/2 ton rocker dump cars, 18" gage, 40# rail car passes

80'-300' from face.

Support System: Normally none, 5/8" x 6' rock bolts as required.

EXCAVATION DATA:

Conventional Rail System

Drilling: 2-6' feed air legs, mounting 3" jackhammers.

Drill Round: 34 holes, 5-2" diameter burncut, circular or box relievers

29 x 1 1/4", average advance 10' per round.

Explosives: 140#. 131# AN/FO, 9#-1 x 6", 60% primers.

Blasting: Electrical, 7 millisecond delays, 10 regular delays.

Powder factor, 7.0#/CY.

Mucking: Eimco, n.odel 21.

Guidance: Transit survey.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

MDN

Ident. No. HS-1 Sheet 1

Abrasiveress N. A.

Pot. Vol. Change, Material

Spec. Gravity, Material

Size (-)0.056": 0

Size (-)0.75": 2.84

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.80%

Plastic Limit 16.06 % Plasticity Index 2.74 % Toughness Index 1.01 Shrinkage Limit 15.12 % Flow Index 2.70

'AATERIAL SIZE (-) 2.0 IN.

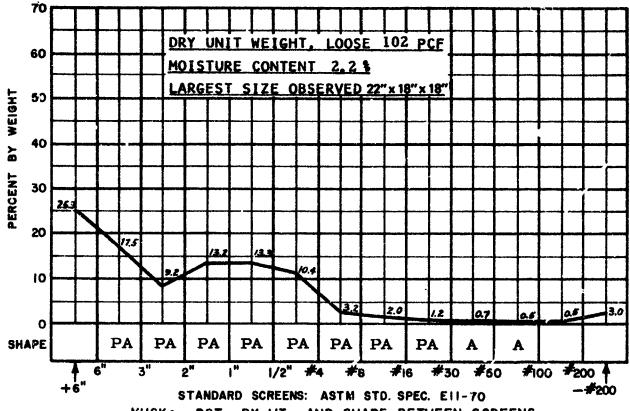
Angle/Repose 1" Drop **@** 3.1 % Moisture, 400 Angl. Slide Steel Plate

@ 3.1 % Moisture, 31°

Apparent Cohesion PSF @ 2.0 % Moisture, 160 Bulk Density PCF

@ 0.0 % Moisture, 99

Angle/Repose 10" Drop @ 3.1 % Moisture, 340 Angle Internal L'riction @ 2.0 % Moisture, 390



PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Phyllite with vein quartz and chlorite schist, highly metamorphosed and folded. High strength. RQD (Est.) 70%. DUW: 187 PCF. Ground water: Dry. Hardness: Schmidt 41.

System Class: Conventional Rail. 7' 6" wide x 7' 6" arch, two air leg drills, 34-10' holes, burn cut. PF 7.0 #/CY. Mucking: Eimco 21. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. HS-1 Sheet 2

Lithology: Metamorphic, mica schist, occasional quartz laminations.

Uniaxial Compressive Strength: 15 KPSI.

RQD: (Estimated) 80%.

Dry Unit Weight: 179 PCF.

Ground Water: Dry Hardness: Schmidt 48.

Youngs Mod.: 12.26 PSI x 10^6 .

Poisson Ratio: 0.17.

TUNNEL DATA:

Size: 11' diameter. Grade: (-) 0.03%.

Ventilation: 3.6 KCFM, exhaust, @ 3475', 20" diameter pipe, 40 HP.

Utility System: 4" airline, 4" waterline, 6" pumpline.

Water Inflow: 40 CPM

Power System: 6600V/440V.

Haulage System: Muck, supplies, personnel by railcars, 10 ton locomotive

17 CY cars, 36" gage, 70# rail.

Support System: Half circle bolted steel lagging in fault zones, pinned to ribs.

EXCAVATION DATA:

Machine: Jarva, 12-1100, Total Weight: NA.

Cutters: 30 Reed steel disc and 6 Jarva TCB disc. Gage: 6 TCB QKC-3W.

2 disc. Interior: 28 steel 3 disc QK3. Center: 2 steel 5 disc QK-1.

Rotation: 10.75 RPM. Torque: 244K# Feet Max. Thrust: 953K# Operating.

Muck Collection: Buckets from face, belt to rear.

Power System: NA. Guidance: Laser.

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75"; 2.614

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 24.90%

Plastic Limit 23.60% Plasticity Index 1.30% Toughness Index 0.25 Shrinkage Limit 22.92% Flow Index 5.3

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose 1" Drop 5.56% Moisture, 39.8° @

Apparent Cohesion PSF 5.56% Moisture, 0

Angle/Repose 10" Drop 5. 56% Moisture, 37. 45°

Angle Slide Steel Plate

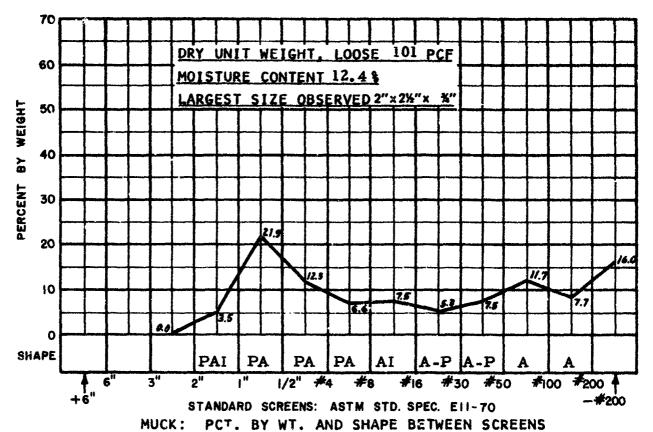
Bulk Density PCF

Angle Internal Friction

5.55% Moisture, 38.75°@

5. 56% Moisture, 84. 76

@ 5. 56% Moisture, 26.20



SUMMARY

Rock Class: Metamorphic: Mica schist, occasional quartz lamination. Medium strength. RQD (Est.) 80%. DUW: 179 PCF. Ground water: Dry. Hardness: Schmidt 48.

System Class: TBM, Jarva 12-1100, 11' dia. 30 Reed and 6 Jarva discs. RPM: NA, Torque: NA, Thrust: NA. Mucking: Buckets to belt. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NY-1 Sheet 2

Lithology: Metamorphic, mica schist, occasional quartz laminations.

Uniaxial Compressive Strength: 13 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 177 PCF.

Ground Water: Dry Hardness: Schmidt 45.

Youngs Mod.: $8.50 \text{ PSI} \times 10^6$.

Poisson Ratio: 0.20.

TUNNEL DATA:

Size: 8'-6" diameter. Grade: (+) 0.03%.

Ventilation: 18 KCFM, exhaust @ 1500', 12" diameter pipe, 40 HP

Utility System: 4" airline, 4" waterline, 4" pumpline.

Water Inflow: 20 GPM. Power System: 6600/440V.

Haulage System: Muck, supplies, personnel by railcars 10 ton locomotive

13 CY cars, 36" gage, 70# rail.

Support System: Half circle bolted steel lagging in fault zones, pinned to ribs.

EXCAVATION DATA:

Machine: Jarva 8-806. Total Weight: NA.

Cutters: 14 Reed disc and 3 Jarva TCB disc. Gag: 3 TCB disc QKC-3W

Interior, 12 TCB disc QC-3, center 2 steel tooth type.

Rotation: 12.5 RPM. Torque: 158K# feet max.

Thrust: 482K# operating.

Muck Collection: Buckets from face, belt to rear.

Power System: NA. Guidance: Laser.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NY-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material

Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.878

ATTFRBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 24.00%

Plasticity Index 0.68%

Plastic Limit 23.32% Toughness Index 0.10 Shrinkage Limit 22.00%

Flow Index 6.70

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose 1" Drop

Apparent Cohesion PSF

Angle/Repose 10" Drop 4. 22% Moisture, 37.950

Angle Slide Steel Plate

@ 4.22% Moisture, 420 @ 4.22% Moisture, 0 Bulk Density PCF

4. 22% Mcisture, 40.17^o@

4.22% Moisture, 80.92

Angle Internal Friction 4. 22% Moisture, 29. 20

70 DRY UNIT WEIGHT, LOOSE 97 PCF 60 MCISTURE CONTENT 7.2 % LARGEST SIZE OBSERVED 2"x 1%" x %" WEIGHT 50 40 PERCENT 30 20 /3.3 10.6 10 2.2 0 SHAPE PAI PA A-P A-P ΑI ΑI 1/2" #4 #30 #50 #8 #16 #100 #200 -*#*2Ò0 STANDARD SCREENS: ASTM STD. SPEC. EII-70

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Mica schist, occasional quartz laminations. Medium strength. RQD (Est.) 90%. DUW. 177 PCF. Ground water: Dry. Hardness: Schmidt 45.

System Class: TBM, Jarva 8-806, 8'6" dia. 14 Reed and 3 Jarva discs and rollers. RPM: NA. Torque: NA. Thrust: NA. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NY-2 Sheet 2

Lithology: Metamorphic, gray mica schist, occasional quartz seams, mica varies from dense fine grained to extremely coarse.

Uniaxial Compressive Strength: 11 KPSI.

RQD: (Estimated) 30% Dry Unit Weight: 165 PCF

Ground Water: Major inflow occurs in faults and fault zones.

Hardness: Schmidt 30.

Youngs Mod.: $4.50 \text{ PSI} \times 10^6 \text{ (Note 2)}$.

Poisson Ratio: 0.25 (Note 2).

TUNNEL DATA:

如果我们是有一个人,我们也就是一个人的,我们也不是一个人的,我们也不是一个人的,我们也不是一个人的,我们也不是一个人的,我们也不是一个人的,我们也会会会会会会会 "我们的,我们就是我们的,我们就是我们的一个人的,我们就是我们的,我们就是我们的,我们就是我们的,我们就是我们的,我们就是我们的,我们就是我们的,我们就是我们的

Size: 11', diameter. Grade: (+) 1 to 3%

Ventilation System: 4 KCFM exhaust 14" pipe.

Utility System: 4" waterpipe, no airline. Water Inflow: 60 gpm, drains in ditch

Power System: 4160/480V

Haulage System: Muck, personnel, supplies by rail cars.

Support System: None, occasional semi-circular plates pinned at spring

line in fault zones

EXCAVATION DATA:

Machine: Jarva, Mark 11-1100, Total Weight: 70 tons

Cutters: 34 Reed, type QK steel multiple disc. Gage: 6 triple disc.

Center: 2-triple disc. Interior: 26 triple disc.

Rotation: Cutterhead, 10.75 RPM

Torque: 244 K ft. #

Anchor Pressure: Maximum 3, 402 K#.

Thrust: 1, 134 K#. operating

Muck System: Buckets from face, belt to rear.

Power System: Four 125 HP, 480V motors drive head, 40 HP 480V motor

drive hydraulic system. Guidance System: Laser

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MON STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. QL-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0. 056": 0

Spec. Gravity, Material Size(-) 0. 75": 2.57

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 24.0 %
Plasticity Index 0.7 %

Plastic Limit 23.3 % Toughness Index 0.17 Shrinkage Limit 22,7 % Flow Index 4.0

MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop

9.8 % Moisture, 39°

Angle Slide Steel Plate

8.4 % Moisture, 40°

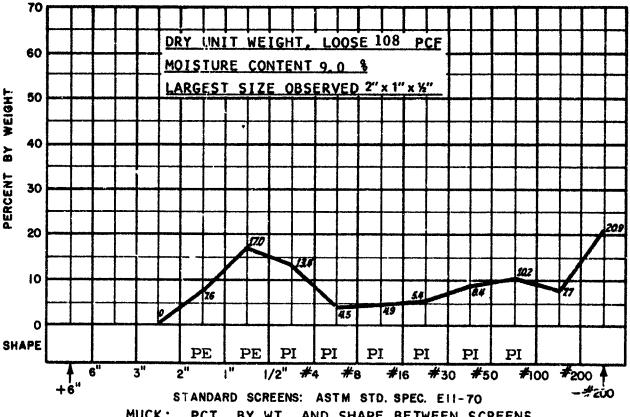
Apparent Cohesion PSF
@ 9.3 % Moisture, 125
Bulk Density PCF

@ 0.0 % Moisture, 75

Angle/Repose 10" Drop

9.8 % Moisture, 37

Angle Internal Friction
9.3 % Moisture, 30



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Metamorphic: Mica schist, dense, fine grained to extremely coarse occasional quartz seams. Medium strength. RQD (Est.) 30%. DUW: 165 PCF. Ground water: Minor inflows at fault zones. Hardness: Schmidt 30.

System Class: TBM, Jarva Mark 11-1100, 11' dia. 36 Reed triple discs. RPM: 10.75. Torque: 244 K ft #. Thrust: 1,134 K #. Mucking: Buckets to belt. Haulage: Rail. Support: Minor, semicircular plates in fault zones.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. QL-1 Sheet 2

Lithology: Sedimentary, graywacke ("argillaceous quartzite"), massive to medium bedded, highly folded and fractured, normal dip of bedding 30° to 45°.

Uniaxial Compressive Strength: 22 KPSI.

RQD: (Estimated) 35%. Dry Unit Weight: 171 PCF.

Ground Water: None.
Hardness: Schmidt 44.
Youngs Mod.: 9.76
Poisson Ratio: 0.20

TUNNEL DATA:

Size: 10' wide x 10.8'. Grade: (+) 2%.

Ventilation System: 8 KCFM, exhaust, 16" diameter pipe, 30 HP @ 1800'

and pressure auxiliary, 8" pipe, 5 HP @ 100'.

Utility System: 6" air line, 4" water line.

Water Inflow: None.

Power System: 2300/480/120V.

Haulage System: Muck, personnel, supplies by railcars, 30" gage, 80# and 60# rail, 10 ton trolley locomotives, 200 and 140 CF bottom dump cars to

skip pocket, 14 ton skips to surface.

Support System: Roof plates and 3/4" x 6' bolts as required.

EXCAVATION DATA:

Conventional Rail System.

Drilling: Hydrojib jumbo, 2 boom, D93 drifters, 1 1/4" round steel on 10' chain feeds.

Drill Round: 36 holes, 1 5/8" diameter, V cut, 8' depth.

Explosives: 210#, 200# Ammonium Nitrate, 10#-7/8" x 8", 70% in ribs and top. Powder factor, 7.0#/CY.

Blasting: Detaprime primers, caps, fuse and igniter cord.

Mucking System: Eimco Model 40 mucker.

Guidance: Transit Lines.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MB-2 Sheet 1

Test Data

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

N. A.

Size (-) 0.056": 0

Size (-) 0.75": 2.678

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 17.70%

Plastic Limit 17.48% Toughness Index 0.03 Shrinkage Limit 16.73%

Plasticity Index 0.22%

Flow Index 7.2

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose 1" Drop

Apparent Cohesion PSF 1.58% Moisture, 250 Angle/Repose 10" Drop 1.58% Moisture, 33.25°

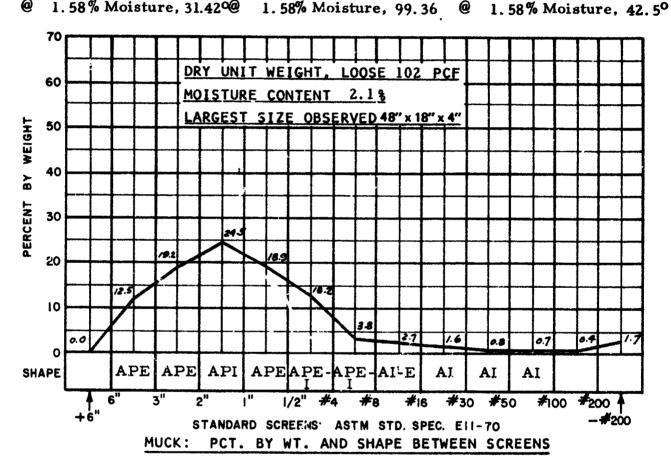
@ 1.58% Moisture, 35.75°@

Bulk Density PCF

Angle Slide Steel Plate 1.58% Moisture, 31.42@

1.58% Moisture, 99.36

Angle Internal Friction



SUMMARY

Rock Class: Sedimentary: Graywacke, massive to medium bedded, normal dip 30° to 45°, highly folded and fractured. High strength. RQD (Est.) 35%. DUW: 171 PCF. Ground water: None. Hardness: Schmidt 44.

Conventional rail, 10' wide x 10.8'. Two machine jumbo, System Class: 36 - 8' holes, V cut. PF 7.0 #/CY. Overhead loader mucking - rail haulage. Support: Rock bolts and plates as required.

MDN STUDY

SYSTEM DATA SHEET MDN

Ident. No. MB-2 Sheet 2

4/1/73

3

Lithology: Sedimentary, sandstone, fine grained, well compacted light brown, over 50 percent quartz.

Uniaxial Compressive Strength: 22 KPSI.

RQD: 92%.

Dry Unit Weight: 166 PCF

Ground Water: Dry.

Hardness: Shore 61, Schmidt 37. Youngs Mod.: 5.38 PSI x 10⁶.

Poisson Ratio: 0.25

TUNNEL DATA:

Size: 18'-1" dia. Grade (-) 7%

Ventilation System: 17 K CFM, exhaust, 36" dia. pipe, 75 HP @ 4100'. Utility System: 2" water line, 4" pump line. No air line - compressor on machine.

Water Inflow: 5-10 gpm Power System: 4160/480V

Haulage System, Muck: 390' of 30" "piggy back" conveyor supported by a monorail advances with the TBM, discharges on a 36" conveyor suspended from the back of the tunnel. Supply and Personnel: Diesel jeeps and trucks.

Support System: 6" x 8.2# channels x 9.5' or 13.5' @ 4' or 2', secured by 4-5/8" x 4' rock bolts. Channels also support monorail.

EXCAVATION DAT 1:

Machine: Robbins 181-122 Weight: 260 tons.

Cutters: 47 Robbins, Steel Disc. Gage: 3-12". Center: 1-7 1/2" triple,

Interior: 43-12".

Rotation: 4 1/2 RPM (Center integral with head)

Torque: 1,720 K ft. #

Thrust: 1,580 K# max., 914 K# operating.

Muck Collection: Buckets fixed to head, discharging on a 30" conveyor.

Power System: Six-480V., 200 HP motors drive head. Hydraulic pumps power thrust and anchor cylinders.

Guidance System: Laser.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. 5-1 Sheet 1

Abrasiveness N. A.

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Pot. Vol. Change, Material

Spec. Gravity, Material Size (-) 0.75": 2.73

Size (-) 0.065": 0

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.185 IN.

Liquid Limit 16.90% Plasticity Index 1.40 %

Plastic Limit 15.50% Toughness Index 0.28

Shrinkage Limit 15.18% Flow Index 5.0

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 6.3 % Moisture, 35° Angle Slide Steel Plate

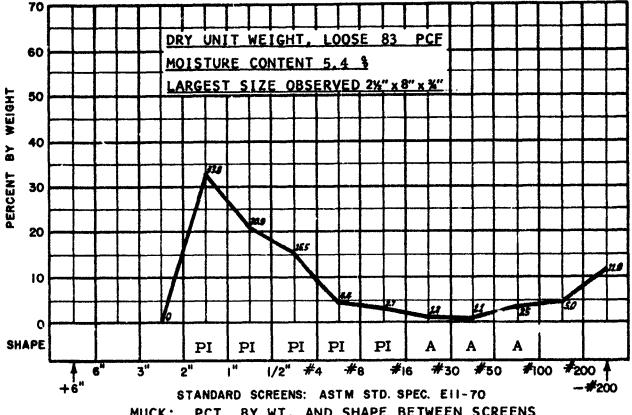
Apparent Cehesion PSF 4.8% Moisture, 280 Bulk Density PCF

Angle/Repose 10" Drop 6.3 % Moisture, 290 Angle Internal Friction

@ 6.3 % Moisture, 28° @

0.0% Moisture, 85.23

@ 4.8 % Moisture, 290



PCT. BY WT. AND SHAPE BETWEEN SCREENS MUCK:

SUMMARY

Rock Class: Sedimentary: Sandstone, fine grained, well compacted, over 50% quartz. High strength. RQD: 92%. DUW: 166 PCF. Ground water: Dry. Hardness: Shore 61, Schmidt 37.

System Class: 'I'BM, Robbins 181-122, 18' 1" dia. 47 Robbins disc cutters. RPM: 4-1/2, 1,720 K FT.# torque, 914 K# thrust. Mucking: Buckets to belt conveyor. Haulage: Traveling conveyor - suspended conveyor - skip to surface. Support: Channels and rock bolts at 4' or 2', continuous.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. 5-1

MDN

Sheet 2

Lithology: Sedimentary, sandstone, fine grained, well compacted light brown, over 50 percent quartz.

Uniaxial Compressive Strength: 22 KPSI.

RQD: 92%.

Dry Unit Weight: 166 PCF.

Ground Water: Dry.

Hardness: Shore 61, Schmidt 37 (Note 4). Youngs Mod.: 5.38 PSI x 10⁶ (Note 4).

Poisson Ratio: 0.25 (Note 4).

TUNNEL DATA:

Size: 18'-1" dia. Grade (+) 2%.

Ventilation System: 17 K CFM, exhaust, 36" dia. pipe, 75 HP@ 4800'. Utility System: 2" water line, 4" pump line. No air line - compressor on machine.

Water Inflow: 5-10 gpm. Power System: 4160/480V.

Haulage System, Muck: 390' of 30" "piggy back" conveyor supported by a monorail advances with the TBM, discharges on a 36" conveyor suspended from the back of the tunnel. Supply and Personnel: Diesel jeeps and trucks.

Support System: 6" x 8.2# channels x 9.5' or 13.5' @ 4' or 2', secured by 4-5/8" x 4' rock bolts. Channels also support monorail.

EXCAVATION DATA:

Machine: Robbins 181-122 Weight: 260 tons.

Cutters: 47 Robbins, Steel Disc. Gage: 3-12". Center: 1-7 1/2" triple,

Interior: 43-12".

Rotation: 4 1/2 RPM (Center integral with head)

Torque: 1,720 Kft #

Thrust 1,580 K# max., 747 K# operating.

Muck Collection: Buckets fixed to head, discharging on a 30" conveyor.

Power System: Four-480V., 200 HP motors drive head. Hydraulic pumps

power thrust and anchor cylinders.

Guidance System: Laser.

NOTE 4; Inferred from Tests of Similar Specimens.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. 7-2

MDN

Sheet 1

Abrasiveness N. A.

California de la companya del companya de la companya del companya de la companya

Pot. Vol. Change, Material Size (-) 0.056":

Spec. Gravity, Material Size (-) 0.75": 2.63

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

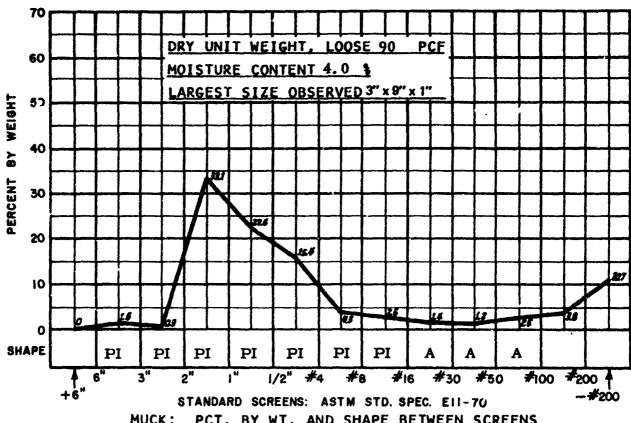
Liquid Limit 23.0 % Plasticity Index 5.37 % Plastic Limit 17.63% Toughness Index 0.78 Shrinkage Limit 17.58 % Flow Index 6.90

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 2.6 % Moisture, 32° Angle Slide Steel Plate @ 2.6 % Moisture, 290

Apparent Cohesion PSF 2.8 % Moisture, 0 Bulk Density PCF 0.0 % Moisture, 92.8

Angle/Repose 10" Drop @ 2.6 % Moisture, 310 Angle Internal Friction @ 2.8 % Moisture, 44°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Sandstone, fine grained, well compacted, over 50% quartz. High strength. RQD: 92%. DUW: 166 PCF. Ground water: Dry. Hardness: Shore 61, Schmidt 37.

System Class: TBM, Robbins 181-122, 18'1" dia. 47 Robbins disc cutters. 4-1/2 RPM, 1,720 K FT # torque, 747 K# thrust. Mucking: Buckets to belt conveyor.

Haulage: Traveling conveyor - suspended conveyor - skip to surface.

Support: Channels and rock bolts at 4' or 2', continuous.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

ldent. No. 7-2 Sheet 2

3

Lithology: Sedimentary, "shale", massive to thinly-laminated, interbedded siltstone and shale, with minor sandstone and limestone layers. Grain size varies from fine to coarse, quartz content from 24 to 33%.

Uniaxial Compressive Strength: Four major beds: 22 K to 29 KPSI, three minor beds: 12 K to 17 KPSI. Weighted Average: 23 KPSI.

RQD: (Estimated) 90%. Dry Unit Weight: 165 PCF.

Ground Water: Dry

Hardness: Shore 41 to 55 parallel to bedding planes, 41 to 54 perpendicular.

Schmidt (Av) 46. Youngs Mod.: 9.52 Poisson Ratio: 0.15

TUNNEL DATA:

Size: 24' wide x 7 1/2' rectangular. Grade: Viries.

Ventilation System: 80-100K CFM, pressure.

Utility System: 4" air, 4" water, 4" pump, where required.

Water Inflow: Normally none.

Power System: 110V. Lighting-all equipment diesel or air powered.

Haulage System: Wagner ST-5 Scooptrams, 16 ton shuttle cars to conveyors, 1 1/2 CY loaders for cleanup. Personnel and supplies, diesel jeeps and trucks.

Support System: 5/8" x 6' rock bolts on 4' x 4' pattern, 11" wide x 10' roof plates where required.

EXCAVATION DATA:

Conventional Trackless System.

Drilling: Two boom hydrojib jumbos, AR93 drifters, 14'feed.

Drill Round: 35 holes, 1 3/4" diameter, 10 1/2 to 11' deep, and 1-6' buster hole, V-cut.

Explosives: 16#-1 1/4" x 8", 75% primers, 32#-1 1/4" x 12" RXL, 60% in lifters, 11# coalite 5Y, 1 1/4" x 12" in back holes, 175# AN/FO in remainder of round. Power factor: 3.5#/CY.

Blasting: Electrical, MS delays. Mucking: Wagner ST-5 Scooptrams.

Guidance: Transit/Laser.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. 11-3 Sheet 1

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

N. A. Size (-) 0.056": Size (-) 0.75": 2.65

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.60% Plasticity Index 0.79 %

Plastic Limit 14.81% Toughness Index 0.26

Shrinkage Limit 14.51 % Flow Index 3.00

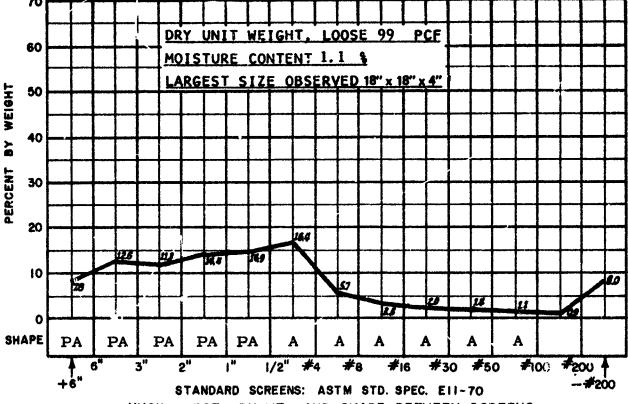
MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop Angle Slide Steel Plate

Apparent Cohesion PSF 1 % Moisture, 25° @ 0.2 % Moisture, 550 Bulk Density PCF

Angle/Repose 10' Drop 1 % Moisture, 250 Angle Internal Friction 0.2 % Moisture, 460

% Moisture, 29^C @ 0.0 % Moisture, 100 70



PCT. BY WT. AND SHAPE BETWEEN SCREENS MUCK:

SUMMARY

Sedimentary: Shale and siltstone, minor sandstone and limestone, thin to massive, fine to coarse grained. High strength. RQD (Est.) 90%. DUW: 165 PCF. Ground water: Dry. Hardness: Shore, 41-55, Schmidt 46.

System Class: Conventional trackless. 24' wide x 7-1/2', rectangular. Two boom jumbo, 35-1-3/4" holes, V-cut. PF 3.5#/CY. Mucking: Scooptram. Haulage: Scooptram and/or shuttle cars to conveyor. Support: Rock bolts, 4' x 4' pattern.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. 11-3 Sheet 2

Lithology: Sedimentary, "shale", massive to thinly laminated, interbedded siltstone and shale, with minor sandstone and limestone layers. Grain size varies from fine to coarse, quartz content from 24 to 33%.

Uniaxial Compressive Strength: Four major beds: 22 K to 29 KPSI, three minor beds: 12 K to 17 KPSI. Weighted Average: 22 KPSI.

RQD: (Estimated) 90%.

Dry Unit Weight: 166 PCF.

Ground Water: Dry.

Hardness: Shore 41.0 to 55 parallel to bedding planes, 41 to 54 perpendicular.

Schmidt (av) 46.

Youngs Mod.: 9.50 PSI x 106 (Note 4).

Poisson Ratio: 0.15 (Note 4).

TUNNEL DATA:

Size: 18' wide x 8 1/2' high, rectangular. Grade: Level.

Ventilation System: 20 KCFM exhaust from face, pressure to entry, 40 HP.

Utility System: 2" water line (250 cfm compressor on machine trailer).

Water Inflow: None.

Power System: Cable to trailer mounted transformer.

Haulage: Muck by diesel shuttle car to conveyor, personnel and supplies by diesel truck.

Support System: 5/8" rock bolts, normally 6' long on 4' x 4' spacing, as required.

EXCAVATION DATA:

Machine: Atlas-Copco 4 head prototype. Weight: 180 LT. Two 4' dia. heads are mounted on each side of center on horizontal booms rotated about vertical pivots. Heads are rotated around boom centerlines by motors and reducers integral with the booms; booms and heads rotate from side to forward positions.

Cutters: 48 Sandvik T.C., drag type, mounted on head peripheries. Leading cutters, 40mm wide, 8 per head; Finish cutters, 120mm wide, 4 per head.

Rotation: Upper heads: 3 1/4 RPM. Lower: 1 5/8 P.PM.

Torque: Head rotation: 80 KW. Boom rotation: 150 LT per boom.

Thrust: 488 LT produced by 4 hydraulic cylinders between advanced and front

Anchorage: Two top and two side cylinders, approximately 1,000 K#.

Muck Collection: Flight conveyors move muck from sides to a central 26" flight conveyor, discharging on a 9 1/2' dia. star wheel. The wheel feeds a 25" belt conveyor, transferring muck to a Joy loader and shuttle cars.

Power System: 4160/600/120V, 60 Hz. Head rotation: 4-80 KW motors, hydraulics: 2-78 KW motors, 2300 psi.

Guidance: Transit/Laser.

NOTE 4: Inferred from Tests of Similar Specimens.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident No. 11-4

Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0, 056": 0

Spec. Gravity, Material Size (-) 0. 75":

2.78

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.80% Plasticity Index 0.20 %

等处现在这些现在是有对外的现代

Plastic Limit 15.60% Toughness Index 0.05

Shrinkage Limit 13.26 % Flow Index 4.00

MATERIAL SIZE (-) 2.0 IN.

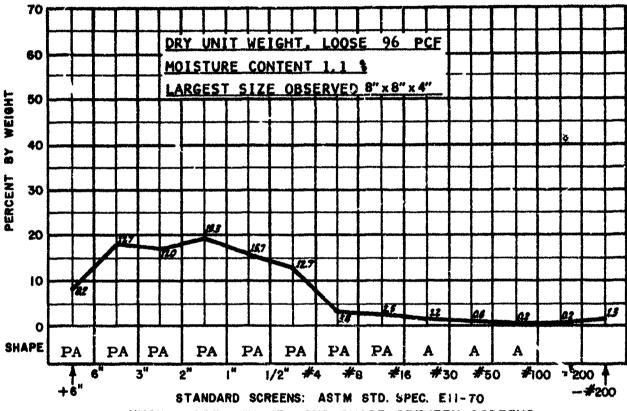
Angle/Repose 1" Drop 0.9% Moisture, 28° Angle Slide Steel Plate

Apparent Cohesion PSF 0.2% Moisture, 282 Bulk Density PCF

Angle/Repose 10" Drop 0.9 % Moisture, 290 Angle Internal Friction 0.2 % Moisture, 540

0.9 % Moisture, 280

0.0% Moisture, 100



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Sedimentary: Shale and siltstone, minor sandstone and limestone, thin to massive, fine to coarse grained. High strength. RQD (Est.) 90%. DUW: 166 PCF. Ground water: Dry. Hardness: Shore 41-55, Schmidt 46.

System Class: TBM, Atlas-Copco. 18' wide x 8-1/2' rect. heading. Sandvik 12/head, 4 heads. RPM 3 1/4 normal. Torque 80 KW/head, TC "drag" bits. 100LT/boom. 480LT thrust. Mucking: Flight conveyor - starwheel-beltloader. Haulage: Shuttle car to conveyor. Support: Rock bolts at 4'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. 11-4

MDN

Sheet 2

Lithology: Sedimentary, "shale", massive to thinly laminated, interbedded siltstone and shale, with minor sandstone and limestone layers. Locally highly faulted and fractured. Grain size varies from fine to coarse.

Uniaxial Compressive Strength: 22 KPSI (weighted average).

RQD: (Estimated) 65%.

I'ry Unit Weight: 168 PCF.

("ound Water: None.

Hardness: Shore 41 to 55 parallel to bedding planes, 41 to 54 perpendicular.

Schmidt (av) 46.

Youngs Mod.: $8.37 \text{ PSI} \times 10^6$.

Poisson Ratio: 0.35.

TUNNEL DATA:

Size: 18'-1" diameter. Grade: (+) 10%.

Ventilation System: 18K CFM, exhaust, 36" diameter pipe, 120 HP @ 7200'.

Utility System: 2" water, 4" pump line from sump av 4200' approximate.

Water Inflow: 5-10 gpm. Power System: 4160/480V.

Haulage System: Muck, 30" - "piggy back" conveyor supported by monorail advances with TBM, feeds a 36" conveyor suspended from back of tunnel.

Supply and Personnel: Diesel jeeps and trucks.

Support System: $6'' \times 8.2 \#$ channels $\times 13.5'$ at 2', secured by $6-5/8'' \times 6'$

rock bolts, lagging under channels.

EXCAVATION DATA:

Machine: Robbins 181-122. Total Weight: 260 tons.

Cutters: 47 Robbins, steel disc, w/Esco rings, Gage: 3-12".

Center: 1-7 1/2" triple. Interior 43-12".

Rotation: 4 1/2 RPM. Torque: 1,147 K#.

Thrust: 769 K#.

Muck System: Buckets fixed to head, discharge on conveyors.

Power System: Four - 480V, 200 HP motors drive head.

Guidance: Laser.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. 72-1 Sheet 1

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material

N. A.

Li

Size (-)0.056" : 0

Size (-)0.75": 2.72

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.00%

Plastic Limit 17.10 %

Shrinkage Limit 15.58 %

Plasticity Index 0.90 % Toughness Index 0.20 Flow Index 4.40

MATERIAL SIZE (-)2.0 IN.

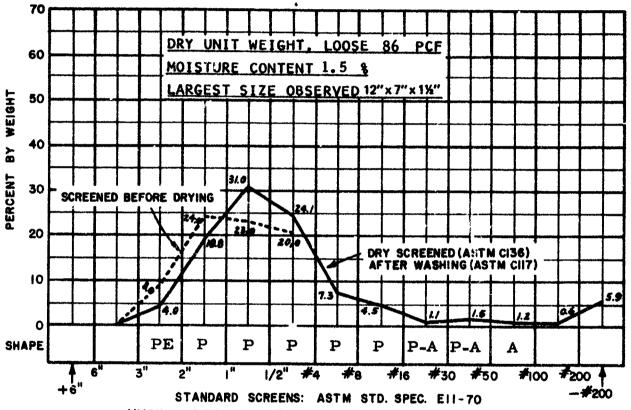
Angle/Repose 1" Drop % Moisture, 36° @ 1.3 Angle Slide Steel Plate

Apparent Cohesion PSF @ 1.0 % Moisture, 170 **Bulk Density PCF**

Angle/Repose 10" Drop @ 1.3 % Moisture, 32° Angle Internal Friction

@ 1.3 % Moisture, 300 @ 0.0 % Moisture, 100

@ 1.0 % Moisture, 410



PCT. BY WT. AND SHAPE [ETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: "Shale" siltstone and shale interbedded, minor sandstone and limestone layers. Massive to thinly laminated, fine to coarse grained. High strength. RQD (Est.) 65%. DUW: 168 PCF. Ground water: None. Hardness: 41 - 55 Shore, Schmidt 46.

System Class: TBM, Robbins 181-122, 18'1" dia. 47 Robbins disc cutters. 4-1/2 RPM, 1,476 K FT # Torque, 769 K# Thrust. Mucking: Buckets to belt. Haulage: Conveyor.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident, No. 72-1 Sheet 2

Lithology: Sedimentary, conglomerate ("breccia") 1/4"-10" rounded to angular boulders, cobbles, pebbles in a predominantly limestone matrix, w/chert, schist diabase fragments, well to moderately consolidated.

Uniaxial Compressive Strength: 11 KPSI (ASTM C-170).

RQD: (Estimated) 65%.
Dry Unit .. eight: 171 PCF
Ground Water: Normally dry.

Hardness: Schmidt 36.

Youngs Mod.: 7.20 PSI x 106 (Note 2).

Poisson Ratio: 0.25 (Note 4).

TUNNEL DATA:

,就是这种人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,也是 第一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就是一个人,我们就

Size: 9' x 10' high. Grade: Level.

Ventilation System: 10 KCFM, pressure, 24" diameter pipe, 50 HP @ 1000', from coil heat exchanger.

Utility System: 6" air line, 2" water line.

Water Inflow: None.

Power System: 4160/480/120V.

Haulage System: Muck, supplies, personnel by railcars, 4 and 6 ton battery

locomotives 44 CF rocker dump cars, 18" gage, 30# rail.

Support System: 5/8" x 6' rock bolts, 3', 4 1/2' or 6' roof plates, 21 bolts

and 7 plates per 5' span.

EXCAVATION DATA:

Conventional Rail System.

Drilling: 3 boom hydraulic jumbo, 7' chain feeds, and 3" bore drifters, 7/8" hex steel.

Drill Round: 42 to 50-1 3/8" diameter holes including 4 hole V cut and 4 hole baby V or 5 hole burn cut, average advance 5 1/2".

Explosives: 150#, 25# Amogel, #4-40% primers and cushion, 125# Carbamite PB. Powder Factor, 8.2#/CY.

Blasting: #6 caps, 8' fuse, detonated electrically, timed by order of connection to igniter cord.

Mucking System: Eimco Model 21 Loader.

Guidance: Laser

NOTE 2: Inferred from D. U. Deere AD 646610-1966. NOTE 4: Inferred from Tests of Similar Specimens.

MDN STUDY 4/1/73

SYSTEM DATA SHEET
MDN

Ident. No. MSU-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size(-) 0.056" : 0

Spec. Gravity, Material Size(-)0.75" : 2.74

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 13.80%

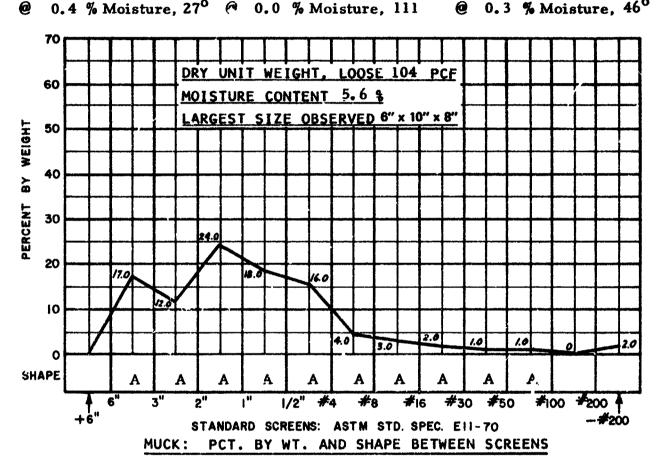
Plastic Limit 12.77 % Plasticity Index 1.03 % Toughness Index 0.32 Shrinkage Limit 10.78% Flow Index 3.20

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 0.4 % Moisture, 350 Angle Slide Steel Plate

Apparent Cohesion PSF @ 0.3 % Moisture, 410 **Bulk Density PCF**

Angle/Repose 10" Drop @ 0.4 % Moisture, 29° Angle Internal Friction @ 0.3 % Moisture, 46°



SUMMARY

1

Rock Class: Sedimentary: Conglomerate, "breccia," 1/4" to 10", limestone, chert, schist, diabase fragments, well to moderately consolidated. Strength: Medium. RQD (Est.) 65%. DUW: 171 PCF. Ground water: Dry. Hardness: Schmidt 36.

System Class: Conventional Rail, 9' wide x 10', three boom jumbo, 42 to 50-1-3/0" holes, burn cut. PF 8.2 #/CY. Mucking: Eimco 21. Haulage: Rail. Support: Rock bolts and plates, continuous.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident, No. MSU-1 Sheet 2

Lithology: Sedimentary, conglomerate, ("breccia") 1/4"-4" boulders, cobbles, and pebbles, rounded to angular in a predominantly limestone matrix, w/chert, schist and diabase fragments, well consolidated.

Uniaxial Compressive Strength: 25 KPSI.

RQD: (Estimated) 80%.

Dry Unit Weight: 169 PCF

Ground Water: None Hardness: Schmidt 45.

Youngs Mod.: 8.70 PSI x 10⁶.

Poisson Ratio: 0.22.

TUNNEL DATA:

Size: 9' wide x 10' high, arched. Grade: Level.

Ventilation System: 9 KCFM, pressure, 24" diameter pipe, 50 HP @ 1300'

from coil heat exchanger.

Utility System: 6" air line, 2" water line.

Water Inflow: None.

Power System: 4160/480/120V.

Haulage System: Muck, supplies, personnel by railcars, 4 and 6 ton battery

locomotives, 44 cu. ft. rocker dump cars, 18" gage, 30# rail.

Support System: 5/8" x 6' rock bolts, 3', 4 1/2' or 6' roof plates, 21 bolts

and 7 plates per 5' span.

EXCAVATION DATA:

Conventional Rail System.

Drilling: 2 boom jumbo, 6' chain feeds and 3" bore drifters.

Drill Round: 50-1 3/8" diameter holes, including 4 hole V cut and 4 hole baby V, 51/2' average advance.

Explosives: 122# average, 40% Amogel #4 or 40% primers and carbamite. Powder Factor, 6.7#/CY.

Blasting: #6 caps, 8' fuse, detonated electrically, timed by order of connection to igniter cord.

Mucking System: Eimco Model 21 loader.

Guidance: Laser.

MDN STUDY 4/1/73 SYSTEM DATA SHILET MDN

Ident. No. MSU-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity. Material Size (-) 0.75": 2.65

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 20.00% Plasticity Index 6.01%

Plastic Limit 13.99% Toughness Index 1.40

Shrinkage Limit 10.67% Flow Index 4.5

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose 1" Drop

Apparent Cohesion PSF 0.83% Moisture, 342° @ 0.83% Moisture, 790 Angle/Repose 10" Drop @ 0.83% Moisture, 29.75°

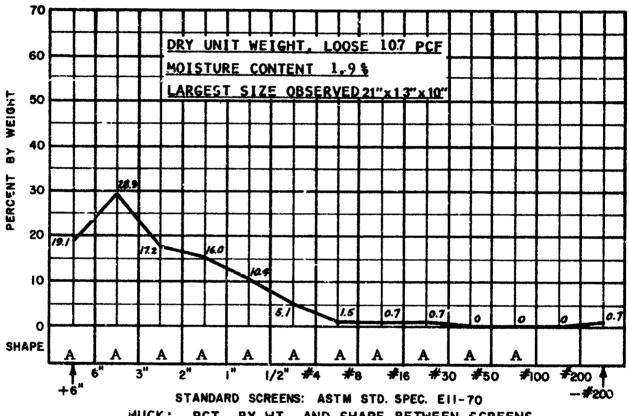
Angle Slide Steel Plate

Bulk Density PCF

Angle Internal Friction

0.83% Moisture, 33.75° 0.83% Moisture, 96.15

@ 0.83% Moisture, 43.45°



HUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Conglomerate, "breccia," 1/4" - 4" limestone, chert schist, diabase fragments, well consolidated. High strength. RQD (Est.) 80%. DUW: 169 PCF. Ground water: None. Hardness: Schmidt 45.

System Class: Conventional Rail. 9' wide x 10'. Two machine jumbo, 50 holes, V cut. PF 6.7 #/CY. Mucking: Eimco 21. Haulage: Rail. Support: Roof plates and rock bolts, continuous.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MSU-2 Sheet 2

2

Lithology: Sedimentary, limestore, light to medium gray, fine grained, some chert nodules, traces to occasional clay partings.

Uniaxial Compressive Strength: 29 KPSI.

RQD: (Estimated) 100 percent.

Dry Unit Weight: 161 PCF.

Ground Water: Table above tunnel, occasional seepage from minor fractures

and faults.

Hardness: Shore, 46, Schmidt 42. Youngs Mod.: $8.70 \text{ PSI} \times 10^6$.

Poisson Ratio: 0.41.

TUNNEL DATA:

Size: 13'-8" diameter. Grade (+) 1/4 percent. Ventilation System: 21 K CFM exhaust, 28" pipe.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 40 to 120 gpm. Power System: 4160/480V.

Haulage System: Muck, supplies, personnel, by rail cars.

Support System: None.

EXCAVATION DATA:

Machine: Alkirk Hardrock. Weight 400 tons. Cutters: 28-Lawrence Mfg. Company, Tungsten Carbide Button, roller, disc, and tricone. Gage: 5-15" TCB roller. Center: 1-24" TCB tricone. Interior: 11-15" TCB disc., 11-15" TCB roller.

Rotation: Center cutter-30 RPM, Head-9 RPM.

Torque: Head 206 K ft. # Thrust: 614 K# operating

Muck Collection: Buckets from face discharging on 24" belt conveyor.

Power System: Electro-Hydraulic. Total HP: 910.

Guidance System: Laser.

MDN STUDY 1/1/73

SYSTEM DATA SHEET MDN

Ident. No. LAW-2 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.065":

Spec. Gravity, Material Size (-) 0.75": 2.83

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.185 IN.

Liquid Limit 12.5 %

Plastic Limit 12.3 % Plasticity Index 0.2 % Toughness Index 0.05

Shrinkage Limit 9.6 % Flow Index 4.0

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 5.4 % Moisture, 390 Angle Slide Steel Plate

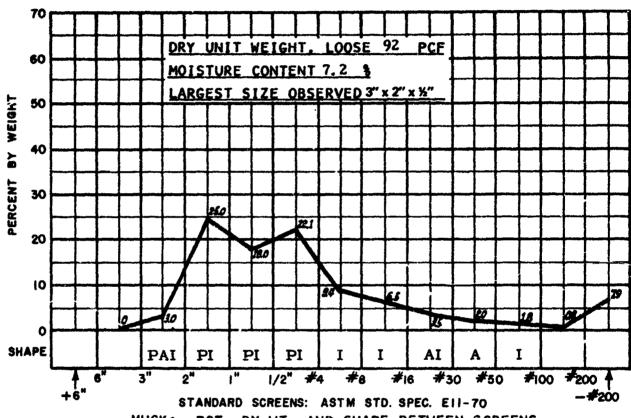
Apparent Cohesion PSF **@** 7% Moisture, 0 **Bulk Density PCF**

Angle/Repose 10 Drop @ 5.4 % Moisture, 380 Angle Internal Friction

@ 5.4 % Moisture, 31° @

0.0% Moisture, 83.97

% Moisture, 300 @ 7



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Sedimentary: Limestone, fine grained, some chert nodules, Rock Class: occasional clay partings. High strength. RQD (Est.) 100%. DUW: 161 PCF. Ground water: Minor. Hardness: Shore 46, Schmidt 42.

TBM, Alkirk Hardrock, 13' 8" dia. 28 Lawrence TCB roller, System Class: disc, tricone cutters. RPM: Center 30, head 9. Torque: 206 K ft #. Thrust: 614 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LAW-2 Sheet 2

4

Lithology: Sedimentary, limestone, light to medium gray, fine grained, some chert nodules, traces to occasional clay partings.

Initial Community Change to occasional C

Uniaxial Compressive Strength: 29 KPSI.

RQD: (Estimated) 100 percent. Dry Unit Weight: 161 PCF.

Ground Water: Table above tunnel, occasional seepage from minor fractures and faults.

Hardness: Shore, 46, Schmidt 42.

Youngs Mod.: 8.70 PSI x 10⁶ (Note 4).

Poisson Ratio: 0.41 (Note 4).

TUNNEL DATA:

Size: 13'-8" diameter. Grade (+) 1/4 percent. Ventilation System: 20 K CFM exhaust, 28" pipe.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 40 to 120 gpm. Power System: 4160/480V.

Haulage System: Muck, supplies, personnel, by rail cars.

Support System: None.

EXCAVATION DATA:

Machine: Alkirk Hardrock. Weight 400 tons. Cutters: 28-Lawrence Mfg. Company, Tungsten Carbide Button, roller, disc, and tricone. Gage: 5-15" TCB roller. Center: 1-24" TCB tricone. Interior: 11-15" TCB disc., 11-15" TCB roller.

Rotation: Center cutter-30 RPM, Head-9 RPM.

Torque: 206 K ft. #.

Thrust: 614 K# operating.

Muck Collection: Buckets from face, discharging on 24" belt conveyor.

Power System: Electro-Hydraulic. Total HP: 910.

Guidance System: Laser.

NOTE 4: Inferred from Tests of Similar Specimens.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LAW-3

Abrasiveness N. A.

Pot. Vol. Change, Material

Size (-)0.065": 0

Spec. Gravity, Material Size(-) 0.75": 2.80

ATTERBERG LIMITS, MATERIAL SIZE (-)0.185 IN.

Liquid Limit 11.8 % Plasticity Index 1.2 %

Plastic Limit 10.6 % Toughness Index 0.41 Shrinkage Limit 10.0 % Flow Index 2.9

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 6.1% Moisture, 41° Angle Slide Steel Plate

Apparent Cohesion PSF 7% Moisture, 0 **Bulk Density PCF**

Angle/Repose 10" Drop @ 6.1 % Moisture, 400 Angle Internal Friction **@** 7 % Moisture, 320

8.4% Moisture, 380

0 0.0% Moisture, 84.04

70 DRY UNIT WEIGHT, LOOSE 93 60 MOISTURE CONTENT 5.5 \$ LARGEST SIZE OBSERVED 3" x 24" x 4" BY WEIGHT 50 40 PERCENT 30 20 10 50 0 SHAPE I I I I PAI PI PAI I PAI 1/2" #4 #8 #30 **#**50 #16 ₱100 ₱200 **4** +6" **--#2**00 STANDARD SCREENS: ASTM STD. SPEC. E11-70

PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, some chert nodules occasional clay partings. High strength. RQD (Est.) 100%. DUW: 161 PCF. Ground water: Minor. Hardness: Shore 46, Schmidt 42.

System Class: TBM, Alkirk Hardrock, 13' 8" dia. 28 Lawrence TCB roller, disc, tricone cutters. RPM: Center 30, head 9. Torque: 206 K ft #. Thrust: 614 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LAW-3 Sheet 2

4

Lithology: edimentary, limestone, light to medium gray, fine grained, some chert nodules, traces to occasional clay partings.

Uniaxial Compressive Strength: 30 KPSI.

RQD: (Estimated) 100 percent.

Dry Unit Weight: 157 PCF.

Ground Water: Table above tunnel, occasional seepage from minor

fractures and faults.

Hardness: Shore, 46, Schmidt 52 (Note 2).

Youngs Mod.: 4.61 PSI x 106.

Poisson Ratio: 0.50

TUNNEL DATA:

Size: 13'-8" diameter. Grade (+) 1/4 percent. Ventilation System: 21 K CFM exhaust, 28" pipe.

Utility System: 6" air line, 2" water line, 6" pump line.

Water Inflow: 40 to 120 gpm. Power System: 4160/480V.

Haulage System: Muck, supplies, personnel, by rail cars.

Support System: None.

EXCAVATION DATA:

Machine: Alkirk Hardrock. Weight 400 tons. Cutters: 28-Lawrence Mfg.

Company, Tungsten Carbide Button, roller, disc, and tricone.

Gage: 5-15" TCB roller. Center: 3-24" TCB tricone. Interior: 11-15"

TCB disc., 11-15" TCB roller.

Rotation: Center cutter-30 RPM, Head-9 RPM,

Torque: Head 206 K ft. #.

Thrust: 540 K ft. #.

Muck Collection: Buckets from face discharging on 24" belt conveyor.

Power System: Electro-Hydraulic. Total HP: 910.

Guidance System: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LAW-4

Abrasiveness N. A.

1

Pot. Vol. Change, Material Size (-)0.056":

Spec. Gravity, Macerial

Size (-) 0.75": 2.73

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 20.2 %

Plastic Limit 20.0 % Plasticity Index 0.2 % Toughness Index 0.05

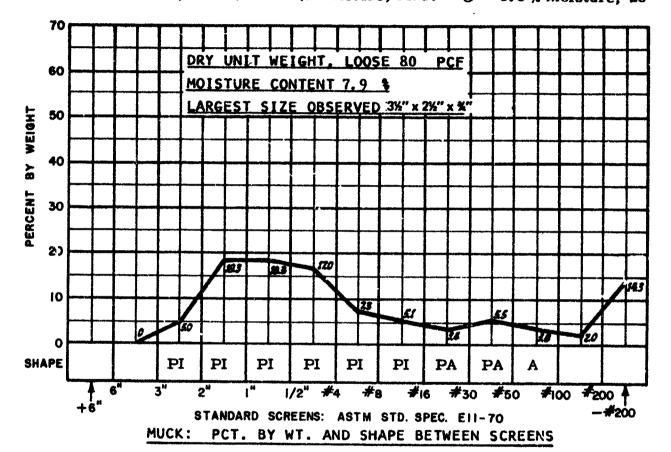
Shrinkage Limit 13.5 % Flow Index 4.7

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 8.9 % Moisture. 42° Angle Slide Steel Plate @ 8.9 % Moisture. 370

Apparent Cohesion PSF 8.8% Moisture, 210 Bulk Density PCF 0.0% Moisture, 84.57 6

Angle/Repose 10" Drop 8.9 % Moisture, 340 Angle Internal Friction 8.8% Moisture, 28°



SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, some chert nodules, occasional clay partings. High strength. RQD (Est.) 100%. DUW: 157 PCF. Ground water: Minor. Hardness: Shore 46, Schmidt 52.

System Class: TBM, Alkirk hardrock, 13' 8" dia. 28 Lawrence TCB roller. disc, tricone cutters. RPM: Center 30, head 9. Torque: 206 K ft #. Thrust: 540 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LAW-4 Sheet 2

4

Lithology: Sedimentary, limestone, gray, fine grained, horizontal joint spacing 6" to 1".

Uniaxial Compressive Strength: 36 KPSI.

RQD: (Estimated) 85% Dry Unit Weight: 166 PCF.

Ground Water: Minor, in fault zones.

Hardness: Schmidt 59 (Note 2).

Youngs Mod.: 10.00 PSI x 106 (Note 2).

Poisson Ratio: 0.30 (Note 2).

TUNNEL DATA:

Size: 11'-2" round. Grade: (+) .2%.

Ventilation System: 4 KCFM, exhaust, 18" pipe, 25 HP. Utility System: 6" air line, 1" water line, 6" pump line.

Water Inflow: 5-10 gpm. Power System: 4680/440V.

Haulage System: Muck, supplies, personnel, rail cars, 5 ton motors, track

gage 24".

Support System: 4" H rings sets in fault zones, occasional pinned steel

lagging.

EXCAVATION DATA:

Machine: Jarva Mark 11-1100. Total weight: 65 tons.

Cutters: 27 Reed steel triple disc and cone. Gage: 4-QK5 steel disc.

Center: 1-QK1 steel cone. Interior: 22-QK3 steel disc.

Rotation: Cutterhead RPM 9.3. Torque: Maximum 170 K ft#.

Thrust: 1, 104 K# maximum, 596 K #-operating. Anchor Pressure: 1,650 K#.

Muck Collection: Bucket from face to 18" belt to 24" belt on gantry.

Power System: 440 volt, 6-50 HP motors drive head and 1-40 HP motor for

hydraulic system.

Guidance: Laser.

NOTE 2; Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MIL-1

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Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0, 056": 0

Spec. Gravity, Material Size (-) 0.75": 2.89

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 16.90% Plasticity Index 1.21%

Plastic Limit 15.69 % Toughness Index 0.24 Shrinkage Limit 15.46 % Flow index 5.00

MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop

2.5 % Moisture, 36°

Angle Slide Steel Plate

2.5 % Moisture. 30°

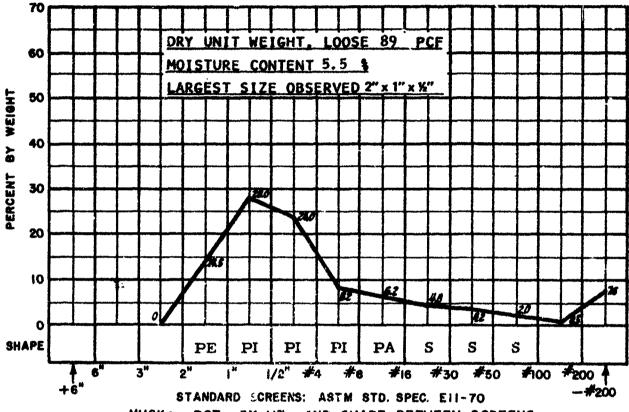
Apparent Cohesion PSF

@ 4.1 % Moisture, 95

Bulk Density PCF

@ 0.0 % Moisture, 86

Angle/Repose 10" Drop @ 2.5 % Moisture, 35° Angle Internal Friction @ 3.5 % Moisture, 35°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, horizontal joint spacing 6" to 1'. Strength: Very high. RQD (Est.) 85%. DUW: 166 PCF.
Ground water: Minor. Hardness: Schmidt 59.

System Class: TBM, Jarva Mark 11-100, 11:2" dia. 27 Reed triple disc cutters/cone RPM: 9.3. Torque: 170 K ft #. Thrust: 596 K #. Mucking: Bucket to belt. Haulage: Rail. Support: H ring sets in fault zones.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MIL-1 Sheet 2

Lithology: Sedimentary, limestone, gray, fine grained, horizontal joint

spacing 6" to 1'.

Uniaxial Compressive Strength: 36 KPSI.

RQD: (Estimated) 85%. Dry Unit Weight: 166 PCF.

Ground Water: Minor, in fault zones.

Hardness: Schmidt 59 (Note 2).

Youngs Mod.: 10.00 PSI x 106 (Note 2).

Poisson Ratio: 0.30 (Note 2).

TUNNEL DATA:

Size: 11'2" round, Grade: (+) .2%.

Ventilation System: 4KCFM, exhaust, 18" pipe, 25 HP. Utility System: 6" air line, 1" water line, 6" pump line.

Water Inflow: 5-10 gpm. Power System: 4680/440V.

Haulage System: Muck, supplies, personnel, rail cars, 5 ton motors,

track gage 24".

Support System: 4" H rings sets in fault zones, occasional pinned steel

lagging.

EXCAVATION DATA:

Machine: Jarva 11-1100, Total weight: 65 tons.

Cutters: 27 Reed steel triple disc and cone. Gage: 4-QK5 steel disc.

Center: 1-QKl steel cone. Interior: 22-QK3 steel disc.

Rotation: Cutterhead RPM 9.3. Torque: Maximum 170 K ft. #.

inrust: 1,104 K# maximum, 596 K#-operating Anchor Pressure: 1,650 K#.

Muck Collection: Bucket from face to 18" belt to 24" belt on gantry.

Power System: 440 volt, 6-50 HP motors drive head and 1-40 HP motor

for hydraulic system.

Guidance: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MIL-2

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Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0. 056": 0

Spec. Gravity, Material Size (-) 0.75": 2.93

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 20.10%
Plasticity Index 3.42%

Plastic Limit 16.68 % Toughness Index 0.56 Shrinkage Limit 16.37 % Flow Index 6.10

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop

© 5.8 % Moisture, 32°

Angle Slide Steel Plate

© 5.8 % Moisture, 30°

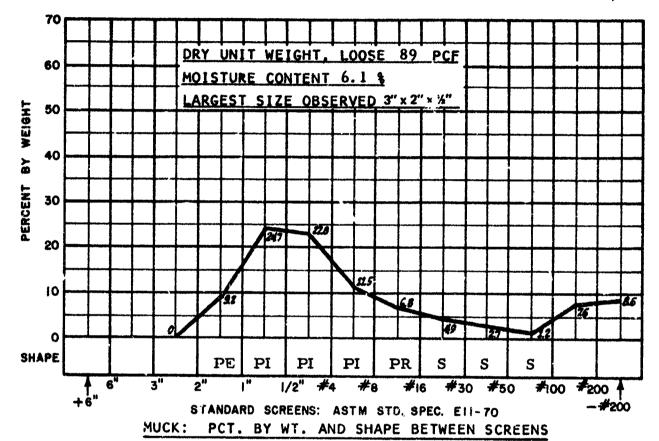
Apparent Cohesion PSF

© 5.0 % Moisture, 110

Bulk Density PCF

© 0.0 % Moisture, 90

Angle/Repose 10" Drop @ 5.8 % Moisture, 30 Angle Internal Friction @ 5.0 % Moisture, 330



SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, horizontal joint spacing 6" to 1'. Strength: Very high. RQD (Est.) 85%. DUW: 166 PCF. Ground water: Minor. Hardness: Schmidt 59.

System Class: TBM, Jarva Mark 11-100, 11'2" dia. 27 Reed triple disc cutters. RPM: 9.3. Torque: 170 K ft #. Thrust: 596 K #. Mucking: Bucket to belt. Haulage: Rail. Support: H ring sets in fault zones.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MIL-2 Sheet 2

Lithology: Sedimentary, limestone, grey, fine grained, horizontal joint spacing 4"-8".

Uniaxial Compressive Strength: 22 KPSI.

RQD: (Estimated) 81%. Dry Unit Weight: 164 PCF

Ground Water: Dry. Hardness: Schmidt 40.

Youngs Mod.: 7.84 PSI x 10°.

Poisson Ratio: 0.46.

TUNNEL DATA:

Size: 11' 2" diameter. Grade: (+) 0.2%.

Ventilation System: 4 KCFM, exhaust, 25 HP (through bore hole).

Utility System: 6" air line, 1" water line, 6" pump line.

Water Inflow: Minor.

Power System: 4680/440V.

Haulage System: Muck, supplies, personnel by railcars, 5 ton locomotive,

24" gage.

Support System: None.

EXCAVATION DATA:

Machine: Jarva, 11-1100, total weight 65 tons.

Cutters: 27 Reed steel disc: 4 gage QK5, 22 interior 2K3, 1 center QK1.

Rotation: 9.3 RPM. Torque: 119K ft. lbs.

Thrust: 639K#

Muck Collection System: Buckets from face, belt to rear.

Power System: 6-50 HP motors drivehead, 1-40 HP motor for hydraulic

system.

Guidance: Laser.

Abrasiveness N. A.

Pot. Vol. Change, Material Size (_) 0. 056" : 0

Spec. Gravity, Material Size (-)0.75": 2.78

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.20%

Plastic Limit 14.40 % Plasticity Index 0.80 % Toughness Index 0.22

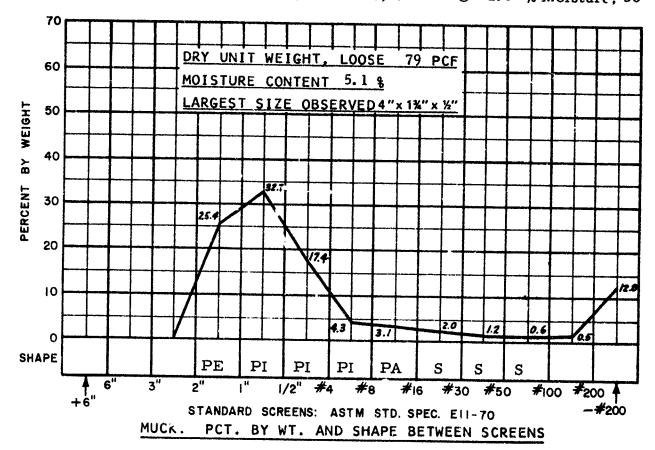
Shrinkage Limit 12.96 % Flow Index 3.50

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose I" Drop @ 2.5 % Moisture. 36° Angle Slide Steel Plate 2.5 % Moisture, 32°

Apparent Cohesion PSF @ 2.3 % Moisture, 60 Bulk Density PCF @ 0.0 % Moisture, 95

Angle/Repose 10" Drop @ 2.5 % Moisture, 32° Angle Internal Friction @ 2.3 % Moisture, 36°



SUMMARY

Rock Class: Sedimentary: Limestone, fine grained, horizontal jointing 4"-8". High strength. RQD: 81%. DUW: 164 PCF. Ground water: Dry. Hardness: Schmidt 40.

System Class: TBM, Jarva 11-1100, 11'2" dia. 27 Reed disc cutters. 9.3 RPM, 119 K ft Torque, 639 K # Thrust. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. MIL-3 Sheet 2

Lithology: Sedimentary, limestone, light grey, fine grained.

Uniaxial Compressive Strength: 26K PSI.

RQD: 100%.

Dry Unit Weight: 168 PCF

Ground Water: Dry. Hardness: Schmidt 44.

Youngs Mod.: 10.63 PSI x 10^6 .

Poisson Ratio: 0.50.

TUNNEL DATA:

Size: 10' 4" diameter. Grade: (+) 0.2%.

Ventilation: 18 KCFM, exhaust, 30" diameter pipe, 90 HP @ 1980'.

Utility System: 3" water line. Water Inflow: 300/400 gpm. Power System: 7200/480V.

Haulage System: Muck, supplies, personnel by railcars, 5 ton locomotive,

4 CY cars, 24" gage, 54# rail.

Support System: None.

EXCAVATION DATA:

Machine: Robbins 105-144. Total weight: 75 tons.

Cutters: 26 Robbins, 12" and 11" discs. 2 Gage and 21 interior, 12" diameter,

3 center, 11" diameter.

Rotation: 6 RPM. Torque: 280K ft. lb. Thrust: 230K lb.

Muck Collection System: Buckets from face, belt to rear.

Power System: 4-100 HP motors drivehead, 50 HP for hydraulic system.

Guidance: Laser.

MDN STUDY

SYSTEM DATA SHEET MDN

Ident. No. EVG-1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056" : 0

Spec. Gravity, Material Size (-) 0.75": 2.81

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.10%

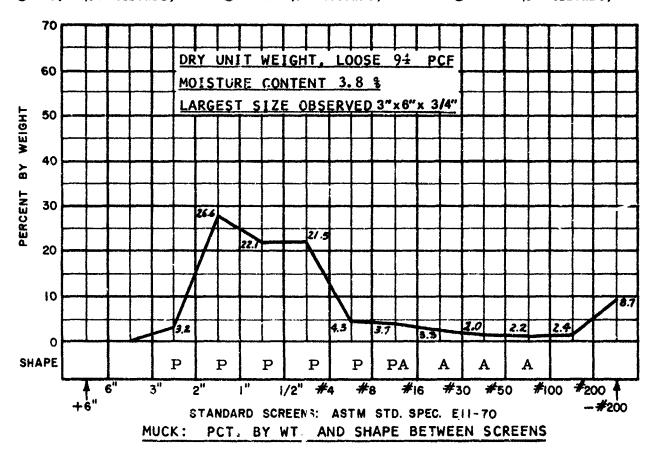
Plastic Limit 13.69% Plasticity Index 1.41% Toughness Index 0.47

Shrinkage Limit 11.57% Flow Index 3.0

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop 3.1 % Moisture, 370 Angle Slide Steel Plate 3.1 % Moisture, 31°

Apparent Cohesion PSF 3.0 % Moisture, 70 Bulk Density PCF 0.0 % Moisture, 104 Angle/Repose 10" Drop 3.1 % Moisture, 310 Angle Internal Friction 3.0 % Moisture, 420



SUMMARY

Rock Class: Sedimentary: Limestone fine grained. High strength. RQD 100%. DUW: 168 PCF. Ground water: Dry. Hardness; Schmidt 44.

System Class: TBM, Robbins, 105-144, 10' 4" dia. 26 Robbins disc cutters. RPM: 6. 280 K ft # torque, 230 K # thrust. Mucking: Buckets to belt. Haulage: Rail. Support. None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. EVG-1 Sheet 2

Lithology: Sedimentary, limestone, light grey, fine grained.

Uniaxial Compressive Strength: 30K.

RQD: 100

Dry Unit Weight: 170 PCF.

Ground Water: Dry. Hardness: Schmidt 45.

Youngs Mod.: 10.82 PSI x 10⁶.

Poisson Ratio: 0.30.

TUNNEL DATA:

Size: 10' 4" diameter. Grade: (+) 0.2%.

Ventilation System: 18 KCFM, exhaust, 30" diameter pipe, 90 HP.

Utility System: 3" water line. Water Inflow: 300/400 gpm. Power System: 7200/480V.

Haulage System: Muck, supplies, personnel by railcars, 5 ton locomotive,

4 CY cars, 24" gage, 54# rail.

Support System: None.

EXCAVATION DATA:

Machine: Robbins 105-144. Total weight: 75 tons.

Cutters: 26 Robbins 12" and 11" discs, 2 gage and 21 interior-12" diameter

3 center-11" diameter.

Rotation: 6 RPM. Torque: 246K ft. lb Thrust: 267K lb.

Muck Collection System: Buckets from face, belt to rear.

Power System: 4-100 HP motors drivehead, 50 HP for hydraulic system.

Guidance: Laser.

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056: 0

Spec. Gravity, Material Size (-) 0.75: 2.473

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 15.50%

Plastic Limit 12.80% Plasticity Index 2.70% Toughness Index 1.00

Shrinkage Limit 12.06% Flow index 2.70

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose I'' Drop @ 3.15% Moisture, 40.1° @ 3.15% Moisture, 470 Angle Slile Steel Plate

Apparent Cohesion PSF Bulk Density PCF

Angle/Repose 10" Drop @ 3.15% Moisture, 34.4° **Angle Internal Friction**

@ 3.15% Moisture, 31.92°@ 3.15% Moisture, 97.78 @ 3.15% Moisture, 36.1°

DRY UNIT WEIGHT, LOOSE 94 PCF 60 MOISTURE CONTENT 2.3% LARGEST SIZE OBSERVED 42"x22"x12" BY WEIGHT 50 40 PERCENT 30 26.7 20 10 2.2 SHAPE NA NA NA NA NA NA NA NA NA 1/2" #4 #8 #30 #50 #100 #200 #16 -#200 STANDARD SCREENS: ASTM STD, SPEC. E11-70

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Limestone, fine grained. High Strength. RQD: 100%. DUW: 170 PCF. Ground water: Dry. Hardness: Schmidt 45.

System Class: 10'-4" dia. 26 Robbins disc cutters. TBM Robbins 105-144. RPM: 6. Torque: 246 K ft #. Thrust: 267 K #. Mucking: Buckets to belt. Haulage: Rail. Support: None.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. EVG-2 Sheet 2

Lithology: Sedimentary, sandstone, medium grained, light brown to red, massive, porous, poorly cemented.

Uniaxial Compressive Strength: 10 KPSI

RQD: (Estimated) 84% Dry Unit Weight: 150 PCF

Ground Water: Generally dry.

Hardness: Schmidt 18.

Youngs Mod.: $1.80 \text{ PSI} \times 10^6 \text{ (Note 2)}$.

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 12'-11" diameter. Grade: (+).125%

Ventilation System: 17 KCFM exhaust, 36" dia. pipe, 100 HP @ 4100'.

Utility System: 3 1/2" water line, 6" air line, 8" pump line.

Water Inflow: 20-100 gpm. Power System: 7300/480V

Haulage System: Muck, supplies, personnel, 10 ton locomotives, 10 CY

cars, 24" gage, 65 lb. rail, 800' trailing floor turnout.

Support System: 4" H full rings, 4' centers: 35%; 13" x 9' pans 3/4" x 7'

rock bolts: 10%.

EXCAVATION DATA:

Machine: Robbins 141-127, total weight: 125 tons.

Cutters: 32 Robbins steel disc. Gage: 6-12". Center: 1-11" triple disc.

Interior: 23-11". (31 Kerfs)

Rotation: Center cutter integral with head, 5.2 or 2.6 RPM.

Torque: 482 K ft #

Thrust: 357 K#, operating. Anchor pressure: 1,000 K#.

Muck Collection: Pickup by buckets fixed to head, discharging on 30" belt

to a 24" x 204' belt on gantry.

Power System: 6-480/240V electric motors drive head. Hydraulic pumps

power thrust and gripper cylinders.

Guidance System: Laser

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

NOTE 5: Assigned Minimum Value.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. LAY-1 Sheet 1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.66

ATTERBERG LIMITS, MATERIAL SIZE (-10.056 IN.

Liquid Limit 21.20%

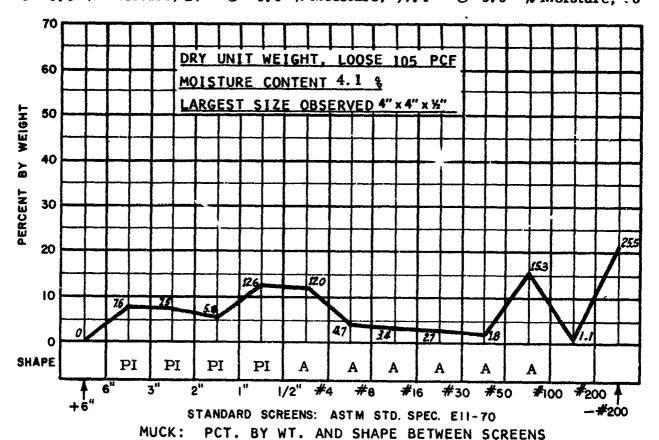
Plastic Limit 17.06 % Plasticity Index 3.14 % Toughness Index 0.52 Shrinkage Limit 15.17% Flow Index 6.00

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 3.6 % Moisture, 37⁹ Angle Slide Steel Plate @ 3.6 % Moisture, 27° @ 0.0 % Moisture, 97.4

Apparent Cohesion PSF 3.6 % Moisture, 210 @ **Bulk Density PCF**

Angle/Repose 10" Drop @ 3.6 % Moisture, 350 Angle Internal Friction @ 3.6 % Moisture, 48°



SUMMARY

Rock Class: Sedimentary: Sandstone, medium grained, massive, porous, poorly cemented. Strength: Medium. RQD (Est.) 84%. DUW: 150 PCF. Ground water: Dry. Hardness: Schmidt 18.

System Class: TBM, Robbins 141-127, 12'11" dia. 32 Robbins disc cutters. RPM: 5.2. Torque: 482 K it # av. Thrust: 357 K # av. Mucking: Buckets to belt conveyor. Haulage: Gantry conveyor to rail cars. Support: Steel ring sets, 35%, roof pans and rock bolts, 10% of 4100'.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident, No. LAY-1 Sheet 2

3

Lithology: Sedimentary, conglomerate, well graded cobbles to pebbles of quartzite poorly to well cemented with reddish brown sandstone, 20%.

Uniaxial Compressive Strength: 22 KPSI: Weighted average of sandstone at 11K (20%) and quartzite at 25K (80%).

RQD: (Estimated) 85%.

Dry Unit Weight: 153 PCF.

Ground Water: Dry.

Hardness: Schmidt 38 (Wtd. Average) Youngs Mod.: 10.80 PSI x 106 (Note 1).

Poisson Ratio: 0.18 (Note 1).

TUNNEL DATA:

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Size: 12' 11" diameter. Grade: (+) 0.125%.

Ventilation System: 15 KCFM, exhaust 36" diameter pipe, 200 HP @ 15000".

Utility System: 3 1/2" water line, 6" air line, 8" pump line.

Water Inflow: 20-100 gpm. Power System: 7300/480V.

Haulage System: Muck, supplies, personnel by railcar 10 ton locomotive,

10 CY cars, 24" gage 65# rail, 800' trailing floor turnout.

Support System: 4" H full rings in bad ground.

EXCAVATION DATA:

Machine: Robbins 141-127. Total Weight: 125 tons.

Cutters: 30 Robbins steel disc, gage 6-12", center 1-11" triple disc

interior 23-11". (31 Kerfs)

Rotation: 5.2 RPM.

Torque: 581K.
Thrust: 585K lb.

Muck Collection: Buckets from face, belt to rear.

Power System: 6-100 HP motors drive head.

Guidance: Laser.

NOTE 1: 80% of Formation.

MDN STUDY 4/1/73

SYSTEM DATA SHEET
MDN

Ident. No. LAY-2 Sheet 1

Abrasiveness N. A.

· Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.65

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 15.00%

Plastic Limit 14.18% Plasticity Index 0.82 % Toughness Index 0.21 Shrinkage Limit 13.80 % Flow index 4.00

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 3.4 % Moisture, 38° @ 3.0 % Moisture, 15 Angle Slide Steel Plate

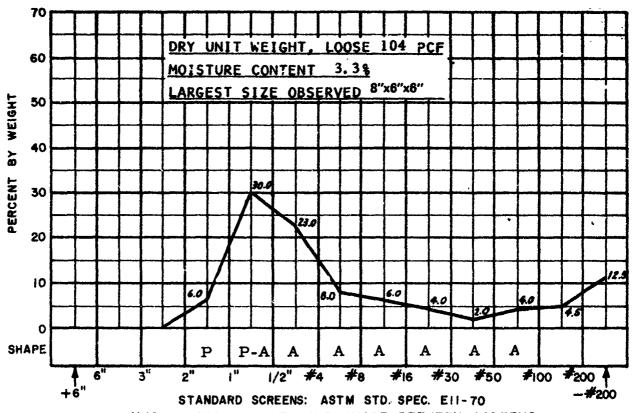
Apparent Cohesion PSF **Bulk Density PCF**

Angle/Repose 10" Drop 3.4 % Moisture, 320 Angle Internal Friction

3.4 % Moisture, 32° @

0.0% Moisture, 88

3.0 % Moisture, 390



PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Conglomerate, quartzite cobbles grading to pebbles, poorly to well cemented with sandstone. High strength. RQD (Est.) 85%. DUW: 153 PCF. Ground water: Dry. Hardness; Schmidt 38 (Wtd. Avg.).

System Class: TBM Robbins 141-127. 32 Robbins disc cutters. RPM: 5.2 Torque: 581 K ft #. Thrust: 585 K #. Mucking: Buckets to belt. Haulage: Rail. Support: Rock bolts, normal, ring sets in bad ground.

MDN STUDY

SYSTEM DATA SHEET

Ident. No. LAY-2

4/1/73

MDN

Lithology: Sedimentary, conglomerate, 80% quartzite pebbles to cobbles, 40% more than 12" dia., to 30". 20% calcareously cemented sandstone matrix.

Uniaxial Compressive Strength: 28 KPSI: Weighted average of sandstone at 7K (20%) and quartzite at 33K (80%).

RQD: (Estimated) 80%.
Dry Unit Weight: 165 PCF.
Ground Water: Saturated

Hardness: Schmidt 38. (Weighted average - see Note 1)

Youngs Mod.: 6.00 PSI x 106 (Notes 1 and 2).

Poisson Ratio: 0.18 (Notes 1 and 2).

TUNNEL DATA:

Size: 12' 11" diameter. Grade: (+) 0.125%.

Ventilation System: 15 KCFM, exhaust 36" diameter pine, 100 HP @ 6700'.

Utility System: 3 1/2" water line, 6" air line, 8" pump line.

Water Inflow: 20-200 gpm. Power System: 7300/480 V.

Haulage System: Muck, supplies, personnel by rail car, 10 ton locomotives

10 CY cars, 24" gage 65# rail, 800' trailing floor turnout.

Support System: 3/4" x 7' rock bolts.

EXCAVATION DATA:

Machine: Robbins 141-127-1. Total Weight: 125 tons.

Cutters: 30 Robbins steel disc, gage: 6-12", center: 1-11" triple disc

interior: 23-11". (31 Kerfs)

Rotation: 5.2 RPM. Torque: 515K ft. lb. Thrust: 585K lb.

Muck Collection: Buckets from face, belt to rear.

Power System: 6-100 HP motors drive head.

Guidance: Laser.

NOTE 1: 80% of formation.

NOTE 2: Inferred from D. U. Deere AD 646610-66

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. CNT-1 Sheet 1

MDN 6

Abrasiveness

Pot. Vol. Change, Material

Spec. Gravity, Material Size (-) 0.75": 2.721

Size (-) 0.056": 0 N. A.

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.0%

Plastic Limit 16.89% Plasticity Index 1.11% Toughness Index 0.36 Shrinkage Limit 15.66%

Flow Index 3.1

MATERIAL SIZE (-) 2.00 IN.

Angle/Repose 1" Drop

Apparent Cohesion PSF

Argle/Repose 10" Drop 6.57% Moisture, 34.55°

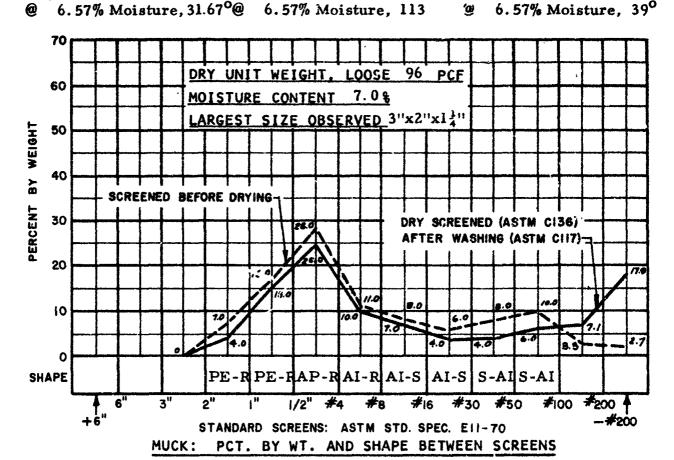
@ 6.57% Moisture, 39.65°@ 6.57% Moisture, 0

'agle Internal Friction

Angle Slide Steel Plate

Bulk Density PCF

6.57% Moisture. 390



SUMMARY

Rock Class: Sedimentary: Conglomerate, 80% quartzite pebbles to cobbles, 40% more than 12" dia. to 30", 20% matrix calcareously cemented sandstone. High strength. RQD (Est.) 80%. DUW: 165 PCF. Ground water: Moderate to wet. Hardness: Schmidt 38. (Weighted Average)

System Class: TBM, Robbins 141-127-1. 32 Robbins disc cutters. RPM: 5.2. Torque: 515K ft. #. Thrust: 585K#. Mucking: Buckets to belt. Haulage: Rail. Support: Rock bolts.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. CNT-1 Sheet 2

6

C-88

Lithology: Sedimentary, siltstone, fine grained, gray, more than 33% quartz, 30% clay, 10% feldspar, 15% mica, chlorite and gypsum.

Uniaxial Compressive Strength: 2 KPSI

RQD: (Estimated) 70% Dry Unit Weight: 142 PCF

Ground Water: Table above tunnel but sealed off by overlying beds.

Hardness: Schmidt 7 (Note 2).

Youngs Mod.: $0.20 \text{ PSI} \times 10^6 \text{ (Note 2)}$.

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 20.5' round, Grade: (+).05%

Ventilation System: 18 KCFM exhaust 30" pipe, 60 HP.

Utility System: 6" air line, 4" pump line

Water Inflow: 50 GPH.

Power System: 4160/440V, rectified to 440 DC for head drive motors.

Haulage System: Muck, supplies, personnel, by 16 CY cars, 15 ton motor,

24" gage 70 lb rail.

Support System: Rock bolts, 8' and $10' \times 3/4''$, set in epoxy with 5' and $13' \times 16$ gage pans, shotcrete placed to prevent air slacking.

EXCAVATION DATA:

Machine: Dresser TB-205, total weight: 200 tons

Cutters: 36 Dresser steel and TCB insert discs, 32 Kennametal U43 and U44 "pick" bits. Gage: 6-#9T5TD1 TCB insert discs. Center: 6-U43TC bits mounted around a 4" chisel. Interior: 30 Type STD steel discs and 26 U44 TC bits mounted on 4 bit blocks.

Rotation: 0-6 RPM range, 5 RPM normal operating.

Torque: Maximum 879 K ft. #., normal operating 586 K ft. #.

Thrust: Maximum 1,583 K # operating 431 K #.

Anchor Pressure: Maximum 6,616 K#.

Muck Collection: Buckets from face to 36" belt to 36" belt on 140' gantry. Power System: Four 180 HP D.C. head motors, one 75 HP for hydraulic

system.

Guidance System: Laser

NOTE 2: Inferred from D. U. Deere AD 646610-1966

NOTE 5: Assigned minimum.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NAV-1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 1.3

Spec. Gravity, Material Size (-)0.75": 3.13

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 36.80%

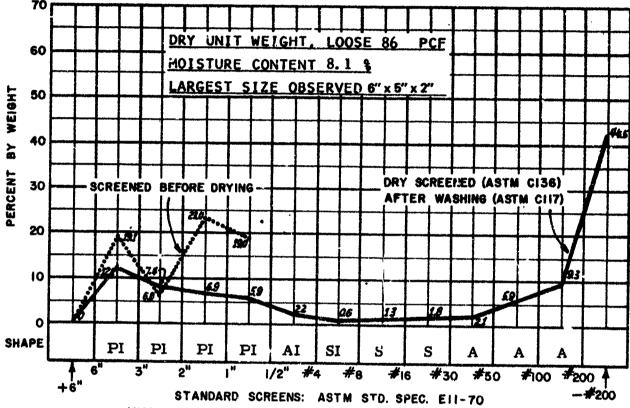
Plastic Limit 23.61% Plasticity Index 13.19% Toughness Index 1.88 Shrinkage Limit 21.04% Flow Index 7.00

MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop @ 7.7 % Moisture, 30° Angle Slide Steel Plate @ 7.7 % Moisture, 300 @ 0.0 % Moisture, 98

Apparent Cohesion PSF @ 7.5 % Moisture, 340 **Bulk Density PCF**

Angle/Repose 10" Drop 7.7% Moisture, 300 Angle Internal Friction 7.5 % Moisture, 36⁶



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Siltstone, fine grained. Strength: Very low. RQD (Est.) 70%. DUW: 142 PCF. Ground water: Minor. Hardness: Schmidt 7.

TBM, Dresser TB 205, 20.5' dia., Dresser disc cutters: System Class: 6TCB and 30 steel, 32 Kennametal, TCB "pick" bits. RPM: 5, 526 K ft #. Torque: 431 K # thrust. Mucking: Buckets to belt. Haulage: Rail. Support: Roof plates and rock bolts, at 3' or 4', continuous.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NAV-1 Sheet 2

3

Lithology: Sedimentary, sandstone, gray, medium grained, massive, friable and porous. Grains angular to subrounded, primarily quartz, poorly cemented.

Uniaxial Compressive Strength: Less than 1 KPSI, disintegrates when wet.

RQD: (Estimated) 60% Dry Unit Weight: 117 PCF

Ground Water: Table above tunnel but sealed off by overlying beds.

Hardness: Schmidt 5 (Note 5).

Youngs Mod.: $0.10 \text{ P3I} \times 10^6 \text{ (Note 5)}$.

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 20.5' diameter. Grade: (+).05%

Ventilation System: 18 KCFM exhaust, 30" pipe, 60 HP.

Utility System: 6" air line, 4" pump line

Water Inflow: 50 GPH.

Power System: 4160/440V, rectified to 440 DC for head drive motors.

Haulage System: Muck, supplies, personnel, by 16 CY cars, 15 ton motor, 24" gage 70 lb rail.

Support System: Rock bolts, 8' and $10' \times 3/4''$, set in epoxy, with 5' and $13' \times 16$ gage pans, shotcrete placed to prevent air slacking.

EXCAVATION DATA:

Machine: Dresser TB-205, total weight: 200 tons

Cutters: 36 Dresser steel and TCB insert discs, 32 Kennametal U43 and U44 "pick" bits. Gage: 6-#9T5TD1 TCB insert discs. Lenter: 6-U43TC bits mounted around a 4" chisel. Interior: 30 Type STD steel discs and 26 U44TC bits mounted on 4 bit blocks.

Rotation: 0-6 RPM range, 5 RPM normal operating.

Torque: Maximum 879 K ft. #., normal operating 586 K ft. #.

Thrust: Maximum 1,583 K #. operating 123 K #.

Anchor Pressure: Maximum 6,616 K #.

Muck Collection: Buckets from face to 36" belt to 36" belt on 140' gantry. Power System: Four 180 HP D. C. head motors, one 75 HP for hydraulic system.

Guidance System: Laser

NOTE 5: Assigned Minimum Value.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. NAV-2 Sheet 1

7 or 4(N)

Abrasiveness N. A.

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Pot. Vol. Change Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.754: 4.72

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 18.20% Plasticity Index 1.29% Plastic Limit 16.91% Toughness Index 0.28 Shrinkage Limit 16.60 % Flow Index 4.50

MATE'RIAL SIZE (-) 2.0 IN.

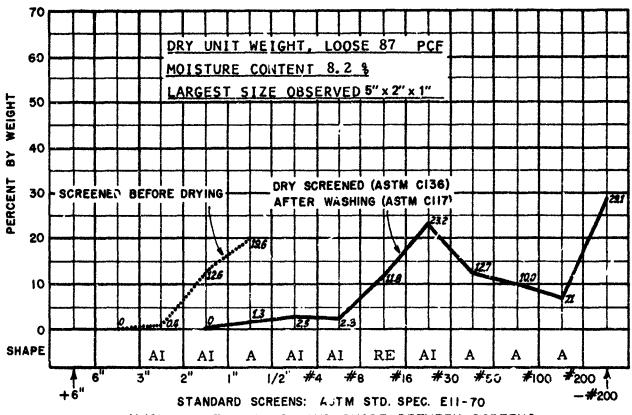
Angle/Repose 1" Drop
@ 8.6% Moisture, 31°
Angle Slide Steel Plate

Apparent Cohesion PSF @ 8.1% Moisture, 45 Bulk Density PCF Angle/Repose 10" Drop
@ 8.6 % Moisture, 280
Angle Internal Friction

@ 8.6% Moisture, 320

@ 0.0% Moisture, 99

@ 8.1 % Mcisture, 28°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Sandstone, massive, friable, porous, medium grained. Very low strength. RQD (Est.) 60%. DUW: 117 PCF. Ground water: Minor. Hardness: Schmidt 5.

System Class: TBM, Dresser TB 205, 20.5' dia. Dresser, disc cutters 6TCB and 30 steel, 32 Kennametal, TCB "pick" bits. RPM: 5, 586 K ft # torque, 123 K # thrust. Mucking: Buckets to belt. Haulage: Rail. Support: Roof plates and rock bolts, at 3' or 4', continuous.

MDN STUDY 4/1/73

SYSTEM DATA SHEET NDN 7 or 4(N) Ident. No. NAV-2 Sheet 2

Lithology: Sedimentary, sandstone, fine grained, brown to dark red massive.

Uniaxial Compressive Strength: 11 KPSI.

RQD: 60%.

Dry Unit Weight: 166 PCF.
Ground Water: Generally dry.

Hardness: Schmidt 36.

Youngs Mod.: 4 47 PSI x 106.

Poisson Ratio: 0.24.

TUNNEL DATA:

Size: 18' 4" diameter. Grade: +.045%.

Ventilation System: 22 KCFM, exhaust, 48" diameter pipe, 2-150 HP

Utility System: 8" air line, 4" water line, 8" pump line.

Water Inflow: 40 gpm.

Power System: 13200/440V.

Haulage System: Muck, supplies, personnel by railcars, 15 ton locomotive

10 CY cars, 36" gage, 50# rail.

Support System: Rock bolts, 5', 6', 8' x 5/8", 24" centers, 14 gauge pans

12' 5" or \$' 6" x 8".

EXCAVATION DATA:

Machine: Lawrence HRT. Total weight: NA.

Cutters: 32 Lawrence Mfg Tungsten Carbide Button, roller, disc and tricone.

Gage: 5 TCB roller, Interior 24 disc and 2 TCB roller, center 1-24"

TCB tricone.

Rotation: Head 11 RPM, center 30 RPM.

Torque: Center cutter 150 HP, head 750 HP, 364K ft. lb.

Thrust: 492K lbs.

Muck Collection: 3uckets from face discharging to 24" belt.

Power System: El ctro-Hydraulic. Total HP: 960

Guidance System: Laser

Lithology: Sedimentary, sandstone, coarse grained, poorly consolidated,

arkosic, with minor layers of thin seamed siltstone.

Uniaxial Compressive Strength: 50 to 150 PSI dry-disintegrates when wet.

RQD: (Estimated) 30%.

Dry Unit Weight: 125 PCF.

Ground Water: Saturated when first opened.

Hardness: Schmidt 5 (Note 5).

Youngs Mod.: 0.10 PSI x 106 (Note 5).

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 10' high by 8' wide, rectangular. Grade (+) 1/2%.

Ventilation System: 5 to 7 KCFM, pressure, 18" dia. vent tube.

Utility System: 4" airline. Water Inflow: 20-25 gpm.

Power System: 440/110V, trailing cable.

Haulage System: Muck, personnel and supplies by rail cars, 24" gage,

40# rail.

STATE STATE OF THE
Support System: None, rock bolts and/or shotcrete in bad ground.

EXCAVATION DATA:

Machine: Alpine Miner, Type F6-A. Total Weight: 11 tons.

Cutters: 72, Kennametal U43K, Carbide tipped, "pick" type. Cutters, mounted on twin ripper heads, rotating about a horizontal axis at 90° to a boom which moves the heads vertically and horizontally.

Rotation: 60 RPM, motor and gear box integral with boom.

Torque: 50.4 HP.

Thrust: Sumping thrust from crawler motors, 2 @ 20.4 HP. Vertical and horizontal by hydraulic cylinders powered by a 10.4 HP electro-hydraulic system.

Anchor Pressure: Crawlers only.

Muck Collection: Central 14" chain conveyor, fed by gathering arms, discharges on an 18" x 30' belt feeding 116' of 20" Serpentix conveyor.

Transverse folds are molded into 20" x 8" long rubber Serpentix sections, which are bolt connected at reinforced flanges connected to an endless chain driven by a sprocket. Folds allow inside edge to compress and outside to expand on curves. Vertebral side rail sections, alternating with straight sections, are supported by wheeled gantry legs riding a 60" gage track, under which cars are spotted.

Power System: 440V, trailing cable.

Guidance System: Transit/Laser.

NOTE 5: Assigned Minimum Value.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

MDN 7 or 3(N) Ident. No. WNG-1 Sheet 1

Lithology: Sedimentary, sandstone, coarse grained, poorly consolidated,

arkosic, with minor layers of thin seamed siltstone.

Uniaxial Compressive Strength: 50 to 150 PSI dry-disintegrates when wet.

RQD: (Estimated) 30%. Dry Unit Weight: 125 PCF.

Ground Water: Saturated when first opened.

Hardness: Schmidt 5 (Note 5).

Youngs Mod.: $0.10 \text{ PSI} \times 10^6 \text{ (Note 5)}$.

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 10' high by 8' wide, rectangular. Grade (+) 1/2%.

Ventilation System: 5 to 7 KCFM, pressure, 18" dia. vent tube.

Utility System: 4" airline. Water Inflow: 20-25 gpm.

Power System: 440/110V, trailing cable.

Haulage System: Muck, personnel and supplies by rail cars, 24" gage,

40# rail.

Support System: None, rock bolts and/or shotcrete in bad ground.

EXCAVATION DATA:

Machine: Alpine Miner, Type F6-A. Total Weight: 11 tons.

Cutters: 72, Kennametal U43K, Carbide tipped, "pick" type. Cutters, mounted on twin ripper heads, rotating about a horizontal axis at 90° to a boom which moves the heads vertically and horizontally.

Rotation: 60 RPM, motor and gear box integral with boom.

Torque: 50.4 HP.

Thrust: Sumping thrust from crawler motors, 2 @ 20.4 HP. Vertical and horizontal by hydraulic cylinders powered by a 10.4 HP electro-hydraulic system.

Anchor Pressure: Crawlers only.

Muck Collection: Central 14" chain conveyor, fed by gathering arms, discharges on an 18" x 30' belt feeding 116' of 20" Serpentix conveyor.

Transverse folds are molded into 20" x 8" long rubber Serpentix sections, which are bolt connected at reinforced flanges connected to an endless chain driven by a sprocket. Folds allow inside edge to compress and outside to expand on curves. Vertebral side rail sections, alternating with straight sections, are supported by wheeled gantry legs riding a 60" gage track, under which cars are spotted.

Power System: 440V, trailing cable.

Guidance System: Transit/Laser.

NOTE 5; Assigned Minimum Value,

MDN STUDY 4/1/73

SYSTEM DATA SHEET

MDN 7 or 3(N) Ident. No. WNG-1

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.71

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 24.90% Plasticity Index 4.93%

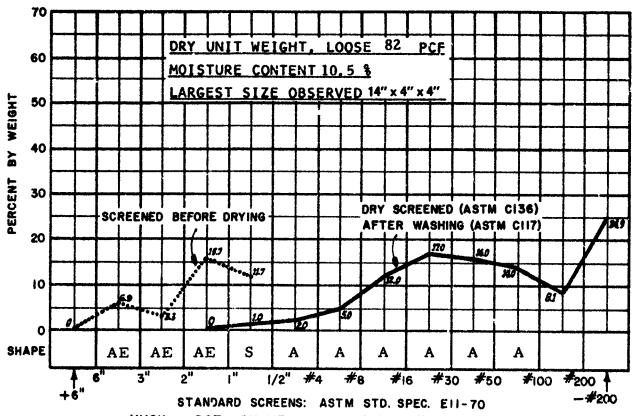
Plastic Limit 19.97% Toughness Index 0.66 Shrinkage Limit 19.94 % Flow Index 7.40

MATERIAL SIZE (-)2.0 IN.

Angle/Repose 1" Drop @ 10.1 % Moisture, 34° Angle Slide Steel Plate

Apparent Cohesion PSF @ 10.6 % Moisture, 0 Bulk Density PCF @ 10.0 % Moisture, 32° @ 0.0 % Moisture, 85

Angle/Repose 10" Drop @ 10.1 % Moisture, 31° Angle Internal Friction @ 10.5% Moisture, 27°



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Sedimentary: Sandstone, coarse grained, poorly consolidated, arkosic, minor thin seamed siltstone. Very low strength. RQD (Est.) 30%. DUW: 125 PCF. Ground water: Saturated. Hardness: Schmidt 5.

System Class: TBM, Alpine F6A, twin head, 10' high x 8' heading. 72 Kennametal TCB pick type bits. 60 RPM, 50.4 HP head torque, 10.4 HP boom power, 40.8 HP sumping thrust. Mucking: Gathering arms-flight conveyor. Haulage: Elevating conveyor - Serpentix conveyor on gantry - rail cars. Support: Normally none.

MDN STÚDY 4/1/73

SYSTEM DATA SHEET MON

Ident. No. WNG-1 Sheet 2

7 or 3(N)

Lithology: Sedimentary, sandstone, coarse grained, poorly consolidated, arkosic, with minor layers of thin seamed siltstone, varying concentrations of replacement silica.

Uniaxial Compressive Strength: 50 to 150 PSI dry-disintegrates when wet.

RQD: (Estimated) 30%

Dry Unit Weight: 125 PCF

Ground Water: Saturated when first opened.

Hardness: Schmidt 5 (Note 5).

Youngs Mod.: $0.10 \text{ PSI} \times 10^6 \text{ (Note 5)}$.

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

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Size: 5' wide x 9' high, nominally rectangular. Grade: Varies.

Ventilation System: 5 to 7 KCFM, pressure, 18" vent tube.

Utility System: 2" air, 1" waterline.

Water Inflow: 20-25 gpm when levels are first opened; generally dry after drainage.

Power System: None in development headings, 440V to scraper hoists, 110V lighting.

Haulage System: Muck is scraped from the face of a cross cut to a slusher drift, cross scraped to a muck raise, and loaded into 4 cu. ft. rocker dump rail cars on main level about 80' below. Scrapers are 42", hoists 15 HP. Personnel access by ladder, supplies by rail cars and air-powered hoists through raises.

Support System: None. Rockbolts in bad ground.

EXCAVATION DATA:

Conventional Scraper-Rail Haulage System.

Drilling: LeRoi Model 35 jackhammers mounted on 6' airfeed legs.

Drill Round: Five hole box or vertical line burn cut, 6' depth, included in 18 hole round, all holes 1 1/2" diameter.

Explosives: 50# Dupont 40% Gelex #2, Powder factor: 5#/cu. yd.

Blasting: Safety fuse and caps.

Mucking System: 42" Scrapers, 15 HP hoists.

NOTE 5: Assigned Minimum Value.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. WNG-2 Sheet 1 Graven ... Erakum

Career

7 or 3(N)

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-) 0.056": 0

Spec. Gravity, Material Size (-) 0.075": 2.72

ATTERBERG LUMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 25.25% Plasticity Index 0.51 %

Plastic Limit 24.74%
Toughness Index 0.13

Shrinkage Limit 23.37 % Flow Index 4.00

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop

@ 9.0 % Moisture, 32°

Angle Slide Steel Plate

@ 9.0 % Moisture, 40°

Apparent Cohesion PSF

@ 9.0% Moisture, 0

Bulk Density PCF

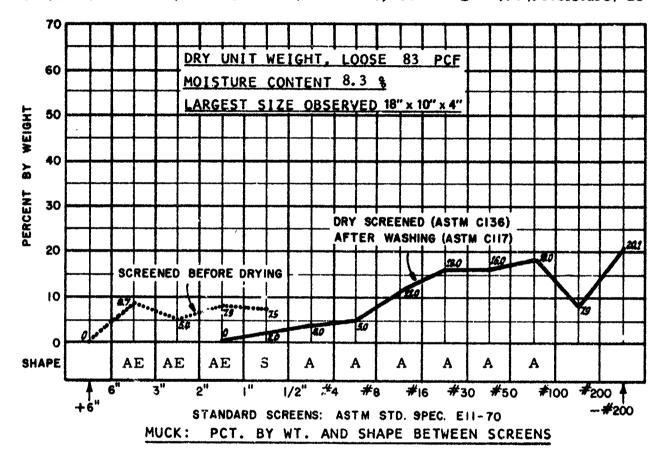
@ 0.0% Moisture, 86

Angle/Repose 10" Drop

@ 9.0% Moisture, 31°

Angle Internal Friction

@ 9.0% Moisture, 28°



SUMMARY

Rock Class: Sedimentary: Sandstone, coarse grained, poorly consolidated, arkosic, minor thin seamed siltstone, varying replacement silica. Very low strength. RQD (Est.) 30%. DUW: 125 PCF. Ground water: Saturated. Hardness: Schmidt 5.

System Class: Conventional Scraper-Rail. 5' wide x 9' high, rectangular. Airleg jackhammer, 18 - 6' holes, burn cut. PF 5#/CY. Mucking: Scraper to raise. Haulage: Rail cars - skip to surface. Support: Normally none.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN 7 or 3(N) Ident. No. WNG-2 Sheet 2

Lithology: Sedimentary, sandstone, arkosic, irregularly

bedded, loosely consolidated with layers and lenses of silty mudstone.

Uniaxial Compressive Strength: Less than one KPSI.

RQD: (Estimated) 15% Dry Unit Weight: 113 PCF

Ground Water: Saturated; water table above tunnel, heading is drained in

advanced by lateral pilot holes in ribs.

Hardness: Schmidt 5 (Note 5).

Youngs Mod.: 0.10 PSI x 106 (Note 5).

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 21 ft., diameter. Grade: (+) 0,2%.

Ventilation System: 20 KCFM, 36" pipe, pressure at face, exhaust in

access.

Utility System: 6" air line, 6" pump line.

Water Inflow: 200 gpm.

Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars.

Support System: Continuous, precast concrete rings 8" and 10" thick,

erected in four-4' segments.

EXCAVATION DATA:

Shield: Robbins 221S ripper, Total weight: 285 tons

Thrust: 3,500 tons total.

Muck Collection System: Muck is ripped from the face by a ripper tooth and drawn through the shield to a 6' conveyor by hydraulic ram with a bucket opposite the ripper tooth.

Power System: Hydraulic.

Guidance System: Laser

NOTE 5: Assigned Minimum Value.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. SF-1

THE PERSON AND THE PE

Abrasiveness N. A.

Pot. Vol. Change, Material

Size (-)0.065":0

Spec. Gravity, Material Size (-)0.185", 2.86

ATTERBERG LIMITS, MATERIAL SIZE (-)0.185 IN.

Liquid Limit 17.75%

Plastic Limit 16.19% Plasticity Index 1.56 % Toughness Index 0.27

Shrinkage Limit 13.94 % Flow Index 5.8

MATERIAL SIZE (-)0. 185IN.

Angle/Repose 1" Drop @ 14.3 % Moisture, 38° Angle Slide Steel Plate

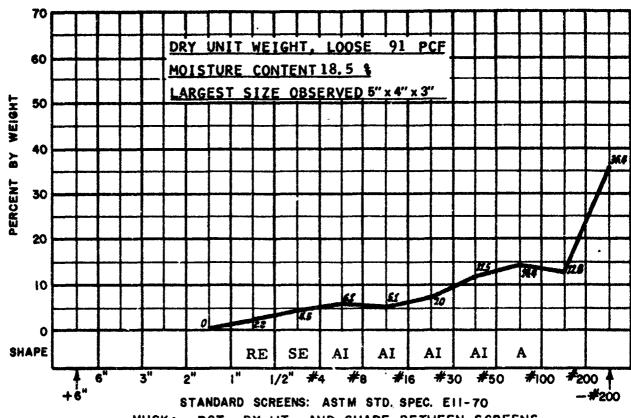
Apparent Cohesion PSF 0 % Moisture, NA Bulk Density PCF

Angle/Repose 10" Drop @ 14.3 % Moisture, 330 Angle Internal Friction

@ 12.5 % Moisture, 36° @

0.0% Moisture, 84.3

@ 13.0 % Moisture, 420



MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Sandstone, arkosic, loosely consolidated, with layers and lenses of silty mudstone. Strength: Very low. RQD (Est.) 15%. DUW: 113 PCF. Ground water: Saturated. Hardness: Schmidt 5.

System Class: Shield, Robbins 221S ripper, 21' dia. Thrust: 3500 tons. Mucking: Hydraulic boom operated bucket scraper to conveyor. Haulage: Rail. Support: Continuous, precast concrete ring segments.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

Ident. No. SF-1 Sheet 2

Lithology: Sedimentary, sandstone, biotite rich siltstone, poorly to well

consolidated, poorly to well sorted.

Uniaxial Compressive Strength: 2 KPSI.

RQD: (Estimated) 50%. Dry Unit Weight: 142 PCF.

Ground Water: Sandstone saturated, water table above tunnel, heading

drained in advanced by lateral pilot holes in ribs.

Hardness: Schmidt 7 (Note 2).

Youngs Mod.: 0.10 PSI x 106 (Note 5).

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 21 ft., round, Grade: (+) 0.2 pct.

Ventilation System: 20 KCFM, 36" pipe, pressure at face, exhaust in

access.

Utility System: 6" air line, 6" pump line.

Water Inflow: 20 gpm.

Power System: 4160/480V.

Haulage System: Muck, personnel, supplies by rail cars.

Support System: Continuous, precast concrete rings 8" and 10" thick,

erected in four 4' segments.

EXCAVATION DATA:

Shield: Robbins 221S ripper, total weight: 285 tons.

Thrust: 3,500 tons total.

Muck Collection System: Muck is ripped from face by a ripper tooth and drawn through the shield to a 6' conveyor by hydraulic ram with a bucket

opposite the ripper tooth.

Power System: Hydraulic.

Guidance System: Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

NOTE 5: Assigned Minimum Value.

MDN STUDY 4/1/73

SYSTEM DATA SHEET

MDN

6 or 2(N)

Ident. No. SF-2

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size (-)0.075": 3.02

ATTERBERG LIMITS, MATERIAL SIZE (-)0.056 IN.

Liquid Limit 31.5 %
Plasticity Index 4.7 %

Plastic Limit 26.8 % Toughness Index 0.61 Shrinkage Limit 21.5 % Flow Index 7.6

MATERIAL SIZE (-)1.0 IN.

Angle/Repose 1" Drop @ 15.1 % Moisture, 38° Angle Slide Steel Plate Apparent Cohesion PSF @ 15% Moisture, 80 Bulk Density PCF Angle/Repose 10" Drop @ 15.1 % Moisture, 36° Angle Internal Friction @ 15 % Moisture, 27°

@ 15.1 % Moisture, 30°

@ 0.0% Moisture, 75.36

79 DRY UNIT WEIGHT, LOOSE 80 PCF 60 MOISTURE CONTENT 17.5 % LARGEST SIZE OBSERVED 3'x2'x8" BY WEIGHT 50 40 PERCENT 30 DRY SCREENED (ASTM C136) 20 BEFORE AFTER WASHING (ASTM CII7) 10 28 0 SHAPE PE RS RS SI SI SI SI SI PE SI #100 #200 1/2" #4 #30 #50 #8 #16 -#200 STANDARD SCREENS: ASTM STD. SPEC. E11-70

MUCK: PCT. BY WT. AND SHAPE BETWEEN SCREENS

SUMMARY

Rock Class: Sedimentary: Sandstone and siltstone, poorly to well consolidated. Strength: Very low. RQD (Est.) 50%. DUW: 142 PCF. Ground water: Saturated. Hardness: Schmidt 7.

System Class: Shield, Robbins 221S ripper, 21' dia. Thrust 3500 tons.

Mucking: Hydraulic boom operated bucket scraper to conveyor. Haulage: Rail.

Support: Continuous, precast concrete ring segments.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN 6 or 2(N)

Ident. No. SF-2 Sheet 2

Lithology: Sedimentary, mudstone, dark gray, fine grained, massive.

Uniaxial Compressive Strength: 11 KPSI dry.

RQD: (Estimated) 90%.

Dry Unit Weight: 144 PCF.

Ground Water: Generally dry. Hardness: Schmidt 42 (Note 2).

Youngs Mod.: 5 0 PSI x 106 (Note 2).

Poisson Ratio: 0.10 (Note 5).

TUNNEL DATA:

Size: 10' high x 9' wide (7'-6" top, 9'-6" bot.om). Grade: (+) 1/2%. Ventilation System: 5 KCFM, exhaust from face, pressure to venthole, 16" flexhaust, 24" vent tube, 2-25 HP Axivane fans.

Water Inflow: Minor

Power System: 440V trailing cable.

Haulage System: Muck, personnel and supplies by rail cars, 36" gage,

45# rail.

Support: 4" WF steel sets at 3' or 6'.

EXCAVATION DATA:

Machine: Alpine Miner, Type F6-A. Total Weight: 11 tons.

Cutters: 40 Kennametal U43KH, Carbide tipped, "pick" type. Cutters mounted on twin ripper heads, rotating about a horizontal axis at 90° to a boom which moves heads vertically and horizontally.

Rotation: 78 RPM, motor and gear box integral with boom.

Torque: 50.4 HP.

Thrust: Sumping thrust from crawler motors, 2 @ 20.4 HP, vertical and horizontal by hydraulic cylinders powered by a 10.4 HP electro-hydraulic system.

Anchor Pressure: Crawlers only.

Muck Collection: Central 14" flight conveyor fed by two gathering arms mounted on an inclined apron, discharges on an 18" elevating conveyor loading rail cars.

Power System: 440V, trailing cable.

Guidance System: Transit/Laser.

NOTE 2: Inferred from D. U. Deere AD 646610-1966.

NOTE 5: Assigned Minimum Value.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident. No. KM-1

Sheet 1

4 or 1(N)

Abrasiveness N. A.

Pot. Vol. Change, Material Size (-)0.056": 0

Spec. Gravity, Material Size (-) 0.75": 2.87

ATTERBERG LIMITS, MATERIAL SIZE (-) 0.056 IN.

Liquid Limit 28.30% Plasticity Index 3, 33 %

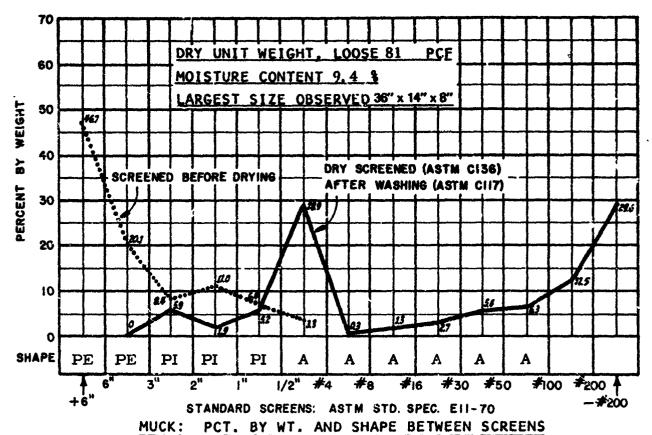
Plastic Limit 24.97 % Toughness Index 0.92 Shrinkage Limit 19.12 % Flow Index 3.60

MATERIAL SIZE (-) 2.0 IN.

Angle/Repose 1" Drop @ 12.7 % Moisture, 290 Angle Slide Steel Plate @ 12.7 % Moisture, 31" @ 0.0 % Moisture, 79

Apparent Cohesion PSF @ 10.9 % Moisture, 37 Bulk Density PCF

Angle/Repose 10" Drop @ 12.7 % Moisture, 28° Angle Internal Friction @ 10.9 % Moisture. 350



SUMMARY

Rock Class: Sedimentary: Mudstone ("shale") fine grained, massive. Medium strength. RQD (Est.) 90%. DUW: 144 PCF. Ground water: Dry. Hardness: Schmidt 42.

System Class: TBM, Alpine F6A, twin head, 10' high x 9' heading. 40 Kennametal TCB pick type bits. 78 RPM, 50.4 HP head torque, 10.4 HP boom power, 40.8 HP sumping thrust. Mucking: Gathering arms - flight conveyor. Haul ...: Elevating conveyor-rail cars. Support: Steel sets at 3' or 6', continuous.

MDN STUDY 4/1/73

SYSTEM DATA SHEET MDN

Ident, No. KM-1 Sheet 2

4 or 1(N)

APPENDIX D

ALGORITHM DEVELOPMENT

In simple regression, it is supposed that with each observation value, there is another quantity which can be observed or somehow related to the observation. After n observations, there exists a series of pairs, (x_1, y_1) , (x_2, y_2) , \cdots , (x_n, y_n) . The question we wish to answer is to determine if there is a relationship between y and x and how this relationship can be obtained.

One may assume that there is such a relationship, and that this relationship is linear. With this assumption, one may write

$$y = \alpha x + \beta \tag{1}$$

The x_i , $i=1,\cdots,n$, are the values of the independent variable x, and the y_i , $i=1,\cdots,n$, are the values of the dependent variable y. α and β are the coefficients which will have to be determined from the observation points.

It is possible that a relationship exists between x and y, but the relationship is not linear. A possible alternate in this case is to find another variable, x^1 , related to x, such that y can then be linearly related to x^1 . The new variable x^1 will then be used in place of x in the discussions that follow.

Assuming that the linear relationship is valid, we can create an error term which is the sum of the squares of all deviations of observed values from the linear Equation (1). Thus the error ϵ is

$$\epsilon = \sum_{i=1}^{n} (y_i - (\alpha x_i + \beta))^2$$
 (2)

and determine α and β so ϵ is minimum. This simple regression is known as the method of "least squares". The solution can be shown to be:

$$\alpha = v_{xy}/s_x^2 \tag{3}$$

$$\beta = \overline{y} - \alpha \overline{x} \tag{4}$$

where

$$s_{x}^{2} = \frac{1}{n-1} \sum_{i=1}^{n} (x_{i} - \overline{x})^{2}$$
 (5)

$$v_{xy} = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x}) (y_i - \bar{y})$$
 (6)

 \overline{x} and \overline{y} are the arithmetic averages of the x_i and y_i respectively.

Equations (3) and (4) give the necessary coefficients in terms of observed values for the predictor Equation (1). If y had been the MDN, and x an in-situ rock property (or some transformation of it), then this simple regression would have resulted in a predictor equation for the MDN.

A procedure similar to the simple regression technique will be applicable if we want to relate a dependent variable y to several independent variables $x_1, x_2, x_3, \cdots, x_{m-1}$. (Note the $x_1, x_2, \cdots, x_{m-1}$ are independent variable and not the observation points themselves). If n observations are taken, then one has the following sets of points: $(y_1, x_1, 1, x_2, 1, x_3, 1, \cdots, x_{m-1}, 1), (y_2, x_1, 2, x_2, 2, x_3, 2, \cdots, x_{m-1}, 2), \cdots, (y_n, x_{1n}, x_{2n}, x_{3n}, \cdots, x_{m-1}, n)$.

A linear relationship is assumed to exist between y and $x_1, x_2, \cdots, x_{m_1-1, n}$. Thus, one has

$$y = \alpha_0 + \alpha_1 x_1 + x_2 y_2 + \cdots + \alpha_{m-1} x_{m-1}$$
 (7)

The coefficients α_0 , α_1 , \dots , α_{m-1} will have to be determined from the n observations of the variables.

To solve for the coefficients requires the manipulation of certain arrays. Defining the following one dimensional arrays:

$$\alpha = \begin{pmatrix} \alpha_0 \\ \alpha_1 \\ \vdots \\ \alpha_{m-1} \end{pmatrix} \qquad ; \quad w = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ \vdots \\ y_n \end{pmatrix}$$
(8)

Let A be the two-dimensional array.

$$A = \begin{pmatrix} 1 & x_{1}, 2 & x_{2}, 1 & \cdots & x_{m-1}, 1 \\ 1 & x_{1}, 2 & x_{2}, 2 & \cdots & x_{m-1}, 2 \\ \vdots & & & \vdots & & \vdots \\ 1 & x_{1}, n & x_{2}, n & \cdots & x_{m-1}, n \end{pmatrix}$$
(9)

Define a vector error by:

$$z = w - A\alpha \tag{10}$$

The scalar error is:

$$\epsilon = z^{T}z = [w - A\alpha]^{T}[w - A\alpha]$$

$$= \alpha^{T}A^{T}A\alpha - (w^{T}A\alpha + \alpha^{T}A^{T}w) + w^{T}w$$
(11)

The derivative with respect to α is:

$$\frac{\mathrm{d}\,\epsilon}{\mathrm{d}\alpha} = 2\mathrm{A}^{\mathrm{T}}\mathrm{A}\alpha - 2\mathrm{A}^{\mathrm{T}}\mathrm{w} \tag{12}$$

For minimum error, $d\epsilon/d\alpha = 0$, thus

$$c = (A^{T}A) \quad A^{T}w \tag{13}$$

A^T is the transpose of the matrix A given by Equation (9).

The general computational procedure is as follows:

- (1) Form the array A as given by Equation (9).
- (2) Obtain the transpose, A^T, from A. This is just a matter of interchanging rows and columns.
- (3) Compute A^TA, then (A^TA)⁻¹, then (A^TA)⁻¹A^T. This involves a series of matrix multiplications and matrix inversion. These techniques are readily available from a computer.
- (4) Form the array w from Equation (8).

- (5) Multiply the result of Step (3) by the result of Step (4). This yields a set of coefficients a_0 a_1 , \cdots , a_{m-1} .
- (6) Test for goodness of fit or the quality of the predictor equation.

A basic assumption is that the predictor equation is linear, and that, the independent variables to use are the observation variables themselves. It may be necessary to define another set of variables x_1' , x_2' , \cdots , x_{m-1}' to use in order to obtain a linear relationship.

It often happens that the independent variables are themselves related. If a linear relationship exists between any two of the independent variables, $(A^TA)^{-1}$ will be singular, i.e., A^TA will have zero determinant, and hence $(A^TA)^{-1}$ cannot be computed. If this is so, α is difficult to compute, and the standard errors of the calculated coefficients are huge, giving an inaccurate predictor equation. This problem can be circumvented by performing the regression analysis with one variable, then with two variables, etc. while being careful when this problem arises. One may combine linearly any two variables that are highly correlated and use the combined variable as in the independent variable.

Good computer routines exist which are available on most computers, including routines for matrix transpose, matrix multiplication and matrix inversion, together with standard routines to compute means and standard deviations of a set of observations. In fact, there also exists software that performs stepwise regression analysis, performing the above calculations plus multiple correlation coefficients and residuals.

In multiple regression to predict an MDN, the MDN is treated as the dependent variable. The set of independent variables may include the following in-situ rock properties:

- (a) Rock classification, quantified, e.g., as Igneous = 1, Metamorphic = 2, Sedimentary = 3
- (b) Compressive strength, CSTR
- (c) Rock quality designation, RQD
- (d) Dry Unit Weight, DUW
- (e) Hardness, H

(f) Ground Water, GW quantified, e.g., as Dry = 1, Minor to Moderate = 2, Wet = 3 Additional parameters peculiar to the excavation method may also be included in the set of independent variables. Some of these variables may be excluded from the analysis; others may be included. The regression analysis may be performed using one of more of these variables.

A set of observations is obtained for each of which an MDN is indicated. For example, suppose a table with the following entries is created: MDN, CLASS, CSTR, RQD, DUW, H, and GW. It is seen that y corresponds to MDN, and CLASS, CSTR, RQD, DUW, H, and GW correspond to x_1, x_2, \ldots , and x_3 , respectively. The matrix in Equation (9) corresponds to the observation points. The array in Equation (8) corresponds to the MDN indicated in Column 1. The predictor equation may be obtained from Equation (13).

Two programs which use the same basic algorithm described above are (a) Program STEPWISE, and (b) Program BMD02R. The first is for a time-sharing mode, whereas the second one is for batch mode processing.

Both programs compute a sequence of multiple linear regression equations in a stepwise manner. At each step, one variable is added to the regression equation. During this step, the numbers (constant and coefficients) that go into the predictor equation are computed. The variable added is the one which makes the greatest reduction in the error sum of squares.

For the second program, transgeneration was possible. That is, new variables were formed as desired, from the old variables, and these new variables were then used in the regression just as the original variables.

APPENDIX E

TRANSPORT SYSTEM AND EQUIPMENT SELECTION

SYSTEM PARAMETERS

The following list of equipment capabilities, system constraints, and MDN applications is taken in part from Report No. FRA-RT-71-5?, "Materials Handling for Tunnels," HN-8080, Holmes & Narver, Inc., and Resource Management Corporation, September 1970, prepared for the U. S. Department of Transportation, Washington, D. C., with additional details provided by the authors. With some differences, the list was incorporated as Section 3.6 of the Annual Technical Report of the first year's program. MDN applicability is based only on muck characteristics, and is subject to constraints imposed by such factors as tunnel size, grade and length, equipment and power cost and availability, and environmental considerations.

UNITIZED SYSTEMS

Conventional Rail Systems

Capabilities and Advantages

Hauling capabilities can be varied by the addition or removal of cars or trains.

Materials, supplies, and personnel can be transported by the system.

Easily adaptable to automatically controlled operation.

Loading and dumping can be done rapidly.

Track extension is relatively simple.

System Constraints

A large percentage of the tunnel cross section is occupied by equipment.

High speeds needed for fast cycle time.

Ideal roadbed and track conditions are necessary if delays cannot be tolerated.

Passing tracks are required in long tunnels.

A secondary system or assisted haulage is needed if vertical grade is over 4 percent.

Supply of materials required for system extension is a major operation at high advance rates.

Small clearances, high speeds, and massive moving equipment combine to produce long delays and serious injuries in the event of accidents.

Combustion products complicate ventilation unless vehicles are powered electrically.

Application

Applicable to any MDN. Special cars would be required for high speed operations with very wet rouck, and special dumping facilities with MDN 6 and 7.

Side Rail Systems

Capabilities and Advantages

Hauling capacities can be varied by the addition or removal of units.

Materials, supplies, and personnel can be transported by the system.

Automatically controlled operation.

Loading and dumping can be done rapidly.

Can be used on much steeper grades than conventional rail systems.

Vertical and horizontal guidance tends to reduce frequency of derails and other accidents.

System Constraints

Power units for side rail systems require electrical bus bars to be extended with the track.

The small size of units in current use limits haulage capacity, and the number of power units can result in maintenance problems and delays.

Continuous bus bars may be a personnel hazard.

Application

All MDN 1 through 7 could be transported by this system. Problems in unloading cars can be expected from MDN 6 and 7 if wet due to the high percentage of fines. The technology of the system is under development; there is no existing application to successful, long distance haulage.

Free Vehicles

Capabilities and Advantages

System capacity can be varied by the number of vehicles or by change in speed.

Materials can be transported inbound and outbound. Guideway for operation is not required.

System Constraints

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Tunnel size limits use of free vehicles in small tunnels unless turnouts are provided.

Roadway must be well graded and maintained to support weight and speed of vehicles.

Fresent design of high capacity vehicles uses excessive amounts of tunnel volume per ton of capacity and does not provide the ability to operate in both directions equally well.

Inability to climb grades of 8 to 12 percent at adequate speeds. Operator required for each vehicle.

Small clearances, high speeds, and massive equipment combine to produce long delays in case of malfunction, and serious injuries in event of accident.

Combustion products complicate ventilation unless vehicles are powered electrically.

Application

MDN 1 through 7 can be transported by free vehicles. Excessive tire wear could be expected in some formations in the MDN 1 and 2 ranges due to lump size and angularity. The system may not be practical for some sites producing muck in the MDN 6 and 7 ranges because of traction and roadbed maintenance problems.

SEMICONTINUOUS SYSTEMS

Belt Conveyors

Capabilities and Advantages

Possible installation overhead or at sides of tunnel leaves floor space for other uses.

Capacities can be increased by changing belt speed. Conveyors can go up or down slopes to 22 degrees.

System Constraints

Supplementary transportation which must be provided for incoming materials and personnel.

Delays inherent as the conveyor is extended from a temporary to a semipermanent installation.

Application

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All MDN can be transported by conveyors. Excessive belt width, damage, and wear can be expected in the MDN 1 and 2 ranges because of piece size and shape unless the material is crushed prior to being place in the system. In the MDN 3 to 7 ranges, through a wide range of water occurrence, considerable material from some formations will stick to the belt causing excessive cleaning and belt wear. In the entire MDN range it is mandatory that the water content be below the point where the muck will slip or flow on the belt or overflow the sides.

Hydraulic Pipelines

Capabilities and Advantages

Capacities adequate for the tonnage from any tunnel in the foreseeable future.

Pipelines use very little space in the tunnel.

Especially adaptable to very wet sites and to hydraulic excavation systems.

Adaptable to any grade including vertical.

System Constraints

Capacity to handle plus 1-inch muck from strong rocks through centrifugal pumps has not been demonstrated in field use.

Crushing, feeding, or scalping equipment for through-centrifugal pump systems, or lock-feed equipment for alternate designs may cause congestion in the near face area.

Large amounts of water are required.

Required electrical power may be difficult to provide for long tunnels in remote areas.

Dewatering, recirculation, and muck disposal systems may be elaborate.

For high advance rates, methods of advancing pumping units and pipelines must be developed.

The heat load from large electrical installations may be difficult to dissipate.

System malfunctions may be hazardous to personnel.

Application

MDN 6 and 7 are most suitable for pumping because of the low percentage of plus # 4 material and a high fines content. Preliminary crushing would be needed for transporting other MDN by a through-centrifugal pump system. Improved feeder and pump applications appear necessary. One trial in a tunnel is reported successful within volume design limitations.

Pneumatic Pipeline

Capabilities and Advantages

Pipelines use very little space in the tunnel. Adaptable to any grade including vertical.

System Constraints

Feeding components congest the tunnel in the near face area.

Power requirements are high.

Muck must be relatively dry.

Crushing or scalping equipment must be used if natural feed is too large for system.

Pipe wear and maintenance may be excessive.

Secondary transportation must be provided for materials and personnel.

Dust at the discharge or from malfunctions may be hazardous to personnel.

Low pressure systems operate at an objectionable noise level.

Application

High pressure systems have not been developed to provide the capacity required for tunnels. Low pressure systems, designed to handled minus 3-inch material, would be suitable for MDN 4 through 7 provided the feed is granular and free flowing. The technology of the system is under development. Reported trials in tunnels were not completely successful.

EQUIPMENT SELECTION

Following are the detailed calculations for the examples of system and equipment selection methods described in Section 3.7. References are cited in the text.

Example 1: Hydraulic Conveying (Reference 1 is cited in text)

Particle Size: Nast 4 (Weighted mean diameter)

	Inches			Average x
Percent	Maximum	Minimum	Average	Percent
11.5	1.0000	0.5000	0.7500	8.625
20.6	0.5000	0.1870	0.3435	7.076
13.6	0.1870	0.0937	0.1404	1.909
42.6	0.0937	0.0059	0.0498	2.121
11.7	0.0059	0.0000	0.0030	0.035
				19.766

19.766/100 = 0.198-Inch

Muck Volume, Weight, and Concentration

Tunnel Area = 76 Square Feet

Advance Rate = 3 Feet Per Hour

Solid Volume = 76 x 3 = 228 Cubic Feet Per Hour

= 3.8 Cubic Feet Per Minute

= .0633 Cubic Feet Per Second

Solid Weight = $228 \times 2.65 \times 62.4 = 37,702$ Pounds Per Hour

= 628.4 Pounds Per Minute

= 10.47 Pounds Per Second

For
$$C_W = 30\%$$
, $C_V = \frac{C_W}{S - (S - 1) \times C_W/100}$
 $C_V = 30/(2.65 - 0.50)$
 $= 30/2.15 = 13.95 \text{ Percent}$

where CW is concentration by weight and S is the specific gravity of the solid.

For
$$C_W = 40\%$$
, $C_V = 40/(2.65 - 0.66)$
 $C_V = 40/1.99 = 20.10 \text{ Percent}$

Critical Velocity

From Figure 1, Reference 1, for a particle diameter of 0.198 inches, a (dimensionless) constant (F_L) of 1.35 is determined for substitution in the formula, Reference 1; in which D = pipe diameter in feet and g is the acceleration of gravity:

$$V_{CR} = F_{L} [2 g D (S - 1)]^{1/2}$$

For 3-Ir h Pipe:

$$V_{CR} = 1.35 [2 \times 32.17 \times (3.068/12) \times (2.65 - 1)]^{1/2}$$

$$= 1.35 (64.34 \times 0.256 \times 1.65)^{1/2}$$

$$= 1.35 \sqrt{27.18}$$

For 4-Inch Pipe:

$$V_{CR}$$
 = 1.35 [64.34 x (4.026/12) x 1.65]^{1/2}
= 1.35 (64.34 x 0.336 x 1.65)^{1/2}
= 1.35 $\sqrt{35.67}$

= 8.05 Feet Per Second

= 7.03 Feet Per Second

Operating Velocity (V_T)

Volume of Mix (V_m) = Volume of Solid x $100/C_V$

For 30 Percent C_{W} , $V_{m} = 0.0633$ Cubic Feet x 100/13.95

= 0.4537 Cubic Feet Per Second

For 40 Percent $C_{\mathbf{W}}$, $V_{\mathbf{m}} = 0.0633$ Cubic Feet x 100/20.10

= 0.3149 Cubic Feet Per Second

Flow Rate $(V_T) = V_m/Area$

For 3-Inch Pipe (Area = 0.0513 Square Feet):

For 30 Percent C_{W} , $V_{T} = 0.4537/0.0513$

= 8.84 Feet Per Second

For 40 Percent C_{W} , $V_{T} = 0.3194/0.0513$

= 6.23 Feet Per Second

For 4-Inch Pipe (Area = 0.0884 Square Feet):

For 30 Percent C_{W} , $V_{T} = 0.4537/0.0884$

= 5.13 Feet Per Second

For 40 Percent C_{W} , $V_{T} = 0.3194/0.0884$

= 3.61 Feet Per Second

Operating Volume (\overline{V}_{m})

For 3-Inch Pipe, 30 Percent C_w:

V = 0.4537 Cubic Feet Per Second

= 27.222 Cubic Feet Per Minute

 $= 27.222 \times 7.4805$

= 203.6 gpm.

Reynolds Number (N_R) (Reference 1)

$$N_{R} = V_{T} \times D \text{ (Feet)} / \text{ Viscosity} = 8.84 \times 0.256 \times 10^{5} / 1.217$$

$$= 2.2630 \times 10^{5} / 1.217$$

$$= 1.8594 \times 10^{5}$$

Drag Coefficient (Cd)

From Reynolds No. Chart = 0.44

Head Loss, Water (Cameron Hydraulic Data, 1951)

Cameron Table, C = 100, $(i_w) = 16.7 \text{ Feet/}100 \text{ Feet}$

Head Loss, Slurry (im)

$$i_{m} = i_{w} \left[1 + 81 \quad \left(\frac{g D (S-1)}{V_{T}^{2}} \right)^{1.5} \quad \frac{C_{V}}{C_{d}^{0.75}} \right]$$

$$81 \frac{\left[gD(S-1)\right]^{1.5}}{v_T^2}$$

$$= 81 \left(\frac{32.17 \times 0.256 \times 1.65}{8.84^2} \right)^{1.5}$$

$$= 81 (13.58/78.15)^{1.5}$$

$$= 81 (0.1737)^{1.5}$$

$$= 81 \times 0.0724 = 5.86$$

$$\frac{C_{V}}{C_{d}^{0.75}} = \frac{0.1395}{0.44^{0.75}} = \frac{0.1395}{0.54} = 0.26$$

$$i_{m} = 16.7[1+(5.86) (0.26)]$$

 $= 16.7 (1 + 1.524) = 16.7 \times 2.524$

= 42.15 Feet/100 Feet = 18.25 psi/100 Feet

Specific Gravity, Slurry

Sp. Gr. =
$$100 \times [C_W]$$
 Solids/Sp. Gr. Solids + C_W Water]⁻¹
= $100 [30/2.65 + 70]^{-1}$ = $100 (11.32 + 70)^{-1}$
= $100/81.32 = 1.23$

BHP

$$= \frac{204 \times 1.23 \times 3,562}{3,962 \times 0.40} = 563.89$$

Maximum Head Loss = 6,914 or 2,994 psi

Maximum BHP = $563.89 \times 165/85 = 1,094$

Equipment

Assume 46 pump stations at 350 feet.

Each pump is 25 hp, and 205 gpm at 150-foot head.

Cost Estimate

Pipe, Installed With Fittings, 16,000 Feet

\$ 160,000

@ \$10 Per Foot

46 Pump Installations @ \$1,000 Each

46,000

Capital Cost, Without Feeders or Power Transmission

\$ 206,000

Example 3: Belt Conveyors (Reference 2 is cited in text)

Surcharge Angle

Design Angle of Repose: 31°

Surcharge Angle = 31° - 16° = 15°

Anticipated Production

6 Feet Per Hour x 257 Square Feet = 1,542 Cubic Feet Per Hour

Design Density

= 170 pcf

1,542 Cubic Feet Per Hour

= 262, 140 Pounds Per Hour

4,369 Pounds Per Minute

Belt Capacity

From Table 3-1, Reference 2:

Surcharge Angle 20°, A = 0.774

Design Muck Weight,

Dry, Lose

Dry Weight Per

Linear Foot $= 0.774 \times 94 = 63.4$ Pounds

= 94 pcf

Edge Distance

= 0.20 Belt Widta (Arbitrary)

Weight Reduction

Factor

= Table 3-9 = 0.45

Reduced Weight Per

Linear Foot

 $= 63.4 \times 0.45 = 28.53$

Belt Speed

4,369 Pounds Dry Weight Per Minute Production

Speed (V) = 4,369/28.53 Pounds Per Linear Foot

= 153 Feet Per Minute

Belt Loading

Dry Weight Per Linear Foot = 28.53 Pounds

Design Moisture

7.9 Percent

W_m = Design Natural

Weight

= 28.53 + 2.25

= 30.8 Pounds Per Foot

Idler Spacing, Belt Weight, and Application Factors

From Reference 2:

Table 4-1: Troughing: 5 Feet; Return: 10 Feet

Table 4-2: Trough Idler Service Factor: 15(A)

Table 4-3: Est. Belt Weight (Wh): 9.2 Pounds Per Foot

Table 4-4: Weight and Lump Factor: 56 (B)

 $A \times B = 840$

Idler Class

From Reference 2:

Figure 4-19: Troughing Idler A.F. = III = 5-Inch Diameter

Figure 4-20: Return Idler A.F. = III = 5-Inch Diameter

6-Inch Diameter Selected for Later Service.

Power .

From Reference 2, the formula for effective tension (T_e) with the reduced friction applicable to a declined belt is stated:

$$T_{e} = L \left[K_{t} \left(K_{x} + 0.01 W_{b} + C_{1} K_{y} W_{b} \right) \right] + C_{1} K_{y} LW_{m} - HW_{m}$$

$$+ Accessories \times C_{1}$$

L = Length = 1,200 Feet
$$C_1 = 0.66 W_b = 9.2 Pounds W_m = 32.8 Pounds$$

=
$$0.00068 (W_b + W_m) = 0.00068 (30.8 + 9.2)$$

= 0.0272

K = Moving Resistance, Belt and Load (Tables 8-2 and 8-3)

= 0.019

$$H = 1200 \times \cos 9^{\circ} - 39 \text{ Feet} = 1200 \times 0.16763$$

= 201.2 Feet

Accessories consist of 2 pulleys and a 10-foot skirt board

$$= (2 \times 40) + (3 \times 30) + 117$$
 (Reference 2)

= 287 Pounds

Expressed in tabular form, the formula components are:

(1)
$$LK_t K_x = 1200 \times 1.0 \times 0.0272 = 32.6$$

(2)
$$LK_t \times 0.01 W_b = 1200 \times 1.0 \times 0.01 \times 9.2 = 110.4$$

(3)
$$LK_t \times C_1 K_v W_b = 1200 \times 1.0 \times 0.66 \times 0.019 \times 9.2 = 138.4$$

(4)
$$C_{1}K_{y}LW_{m} = 0.66 \times 0.019 \times 1200 \times 32.8 = 493.6$$

(5)
$$-HW_{m} = 201.2 \times 32.8 = -6596.1$$

(6) Accessories x
$$C_1 = 287 \times 0.66 = 189.4$$

$$T_e = Sum of (1) through (6) = -5631.7$$

Substituting in the power formulas, Reference 2:

Belt hp =
$$T_e \times V/33000$$

$$= -5631.7 \times 153/33000 = 26.1$$

Reference 2)

$$= -26.1 + 1.6 = 24.5.$$